Chapter 2: Mandatory Measures

2.0 SUMMARY

This chapter discusses the conservation features and devices mandated by the *Energy Efficiency Standards* (standards). The Introduction (Part 2.1) explains the relationship of mandatory measures to the other building features that can be used for compliance with the standards. Part 2.2 discusses "proof of compliance." Parts 2.3, 4 and 5 cover each mandatory measure, grouped into building envelope, HVAC and hot water systems, and lighting and appliances. Each mandatory measure discussion includes, at a minimum, the language from the standards followed by compliance and enforcement guidelines and information. Part 2.6 contains sample forms used for mandatory measure compliance.

CHAPTER OVERVIEW:

Applicable sections of the California Code of Regulations, Title 24, Part 6: 101(b), 110-111, 112(b), 114-116, 117(a), 118., 150.

2.1 INTRODUCTION

All new residential construction covered by the standards and explained in this manual must meet or exceed certain minimum conservation levels, regardless of the compliance approach. These minimum requirements are referred to in the standards as ***mandatory measures.***

The building envelope includes the foundation, floor, walls, doors, windows, roofs and skylights. The building envelope measures regulate the levels and quality of insulation in the building, the amount of air leaking into or out of the building through various components such as door and window frames, and the labeling of windows and other fenestration products for their rated overall U-value and solar heat gain coefficient (SHGC).

An energy efficient building envelope will minimize the heat losses out of and heat gains into the dwelling. As a result, the space-conditioning system will use less energy to control the indoor temperature. This section discusses the mandatory features required to assure that the building envelope meets a minimum thermal performance level. Figure 2-1 graphically illustrates many of the mandatory measures required to be installed.

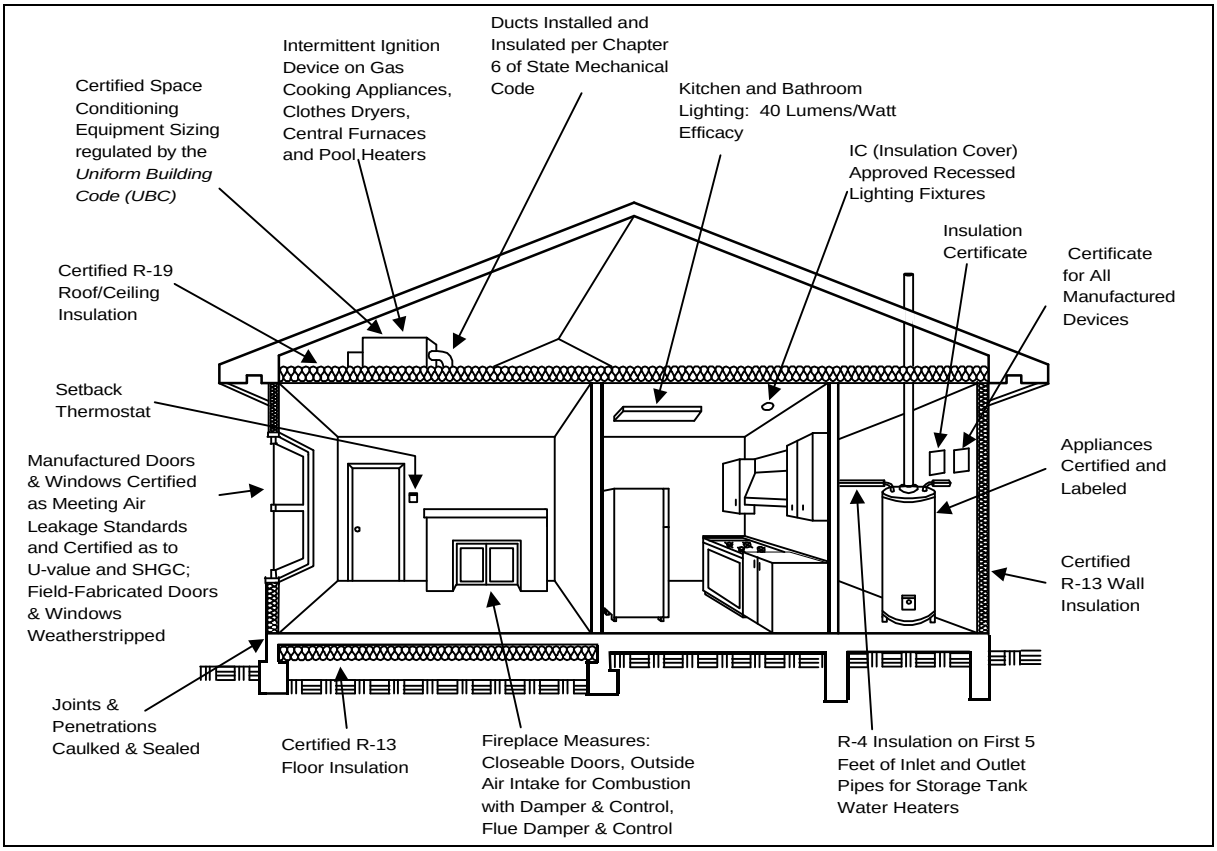


Figure 2-1: Installed Mandatory Measures

The mandatory measures represent a minimum level of conservation that may be in addition to or superseded by features required for compliance if more stringent.

2.2 COMPLIANCE

Introduction

Compliance

Proof of compliance with mandatory measures at the documentation stage is shown by including a Mandatory Measures Checklist (see MF-1R form in Part 2.6 or Appendix A) along with other compliance documentation.

Proof of compliance at the construction phase is shown by completing an Installation Certificate or insulation Certificate (see the CF-6R and IC-1 forms in Part 2.6 or Appendix A).

Both of these forms must be made available to the inspector during appropriate inspections, and copies must be provided to the original occupants of the building. See Chapter 1 for a full discussion of the Energy Code documentation requirements.

2.3 BUILDING ENVELOPE MANDATORY MEASURES

Introduction

Insulation

The R-value of insulation (or any material or building component) is the measure of its thermal resistance expressed in ft^2-hr-°F/Btu. This value may be obtained from Appendix B or from manufacturer's literature.

The rated R-value of mineral fiber (batt) insulation is based upon its fully expanded thickness. When the insulation is compressed, the R-value is reduced. For example, an R-19 batt of insulation expands to a thickness of six inches. If it is compressed into 2x6 framing with an actual depth of 5.5 inches, the insulation R-Value is lowered to R-17.8. See Table 2-1 for some common compressed insulation values.

Table 2-1: R-Values for Compressed Mineral Fiber Batt Insulation[1]

Standard R-Value	Nominal Lumber Size	Actual Cavity Depth	Compressed R-Value
13 (3.625")	2x4	3.5"	13
15 (3.5")	2x4	3.5	15
19 (6.25")	2x6	5.5"	17.8
21 (5.5")	2x6	5.5	21
22 (6.75")	2x6	5.5"	20
30 (9.5")[2]	2x10	9.25"	30
38 (12")[2]	2x12	11.25"	37

1. Based on manufacturer's data.

2. Note that batt insulation with these R-values is available in smaller thicknesses. R-30 may be achieved with an 8.25-inch to 8.5-inch batt, and R-38 may be achieved with a 10.25-inch to 10.5-inch batt. If this thinner insulation is used in the framing sizes listed here, the insulation would retain its full rated R-value because it would not be compressed.

The R-value of loose fill insulation depends on proper installation. See page 2-11.

Energy Code

Installation of Certified Insulating Material (Section 118)

(a) ***Certification by Manufacturers.*** *Any insulation of the type and form listed below may be installed only if the manufacturer has certified that the insulation complies with the California Quality Standards for Insulating Material, Title 20, Chapter 4, Article 3. See Appendix 1-A for availability of directories of certified insulating material.*

Type	*Form*
Aluminum foil	*reflective foil*
Cellular glass	*board form*
Cellulose fiber	*loose fill and spray applied*
Mineral aggregate	*board form*
Mineral fiber	*blankets, board form, loose fill*
Perlite	*loose fill*
Phenolic	*board form*
Polystyrene	*board form, molded extruded*
Polyurethane	*board form and field applied*
Polyisocyanurate	*board form and field applied*
Urea formaldehyde	*foam field applied*
Vermiculite	*loose fill*

(b) ***Installation of Urea Formaldehyde Foam Insulation.*** *Urea formaldehyde foam insulation may be applied or installed only if:*

1. *It is installed in exterior sidewalls; and*

2. *A four mil thick plastic polyethylene vapor barrier or equivalent plastic sheeting vapor barrier is installed between the urea formaldehyde foam insulation and the interior space in all applications.*

(c) ***Flamespread rating.*** *All insulating material shall be installed in compliance with the flamespread rating and smoke density requirements of Sections 2602 and 707 of the Title 24, Part 2.*

Compliance/ Plan Check

Installation of Certified Insulating Material

The California Quality Standards for Insulating Materials, which became effective on January 1, 1982, ensure that insulation sold or installed in the state performs according to the stated R-value and meets minimum quality, health and safety standards.

Manufacturers must certify all insulating materials to comply with California Quality Standards for Insulating Materials. Builders may not install the types of insulating materials indicated in Section 118(a) unless the product has been certified by the manufacturer. Builders and enforcement agencies should use the Department of Consumer

Affair's *Consumer Guide and Directory of Certified Insulation Material* to check compliance. Building departments receive a copy of the current directory. If an insulating product is not listed in the most recent edition of the directory, or to purchase a directory, contact the Department of Consumer Affairs Thermal Insulation Program at (916) 574-2065.

NOTE:

Urea Formaldehyde is restricted by Section 1553 of Title 20. If such products are certified, this is verification that the restrictions of Section 1553 were met. The restrictions in Section 118 also apply.

California Quality Standards for Insulating Materials also require that all exposed installations of faced mineral fiber and mineral aggregate insulations must use fire retardant facings. Exposed installations are those where the insulation facings do not touch a ceiling, wall or floor surface, and faced batts on the underside of roofs with an air space between the ceiling and facing. These installations require insulation that has been tested and certified not to exceed a flame spread of 25 and a smoke development rating of 450.

Inspection

Installation of Certified Insulating Material

Flame spread ratings and smoke development ratings are shown on the insulation or packaging material or may be obtained from the manufacturer.

An Insulation Certificate (IC-1) signed by the insulation installer must be posted in a conspicuous location or made available with the building permit at the time of installation and inspections.

Energy Code

Ceiling Insulation (Section 150(a))

(a) ***Ceiling Insulation.*** *The opaque portions of ceilings separating conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of either 1 or 2 below:*

1. *Ceilings shall be insulated between wood framing members with insulation resulting in an installed thermal resistance of R-19 or greater for the insulation alone.*

   ALTERNATIVE to Section 150(a)1.: Insulation which is not penetrated by framing members may meet an R-value equivalent to installing R-19 insulation between wood framing members and accounting for the thermal effects of framing members.

2. *The weighted average U-value of ceilings shall not exceed the U-value that would result from installing R-19 insulation between wood framing members in the entire ceiling and accounting for the effects of framing members.*

Compliance/ Plan Check

Ceiling Insulation

R-19 is a mandatory *minimum* level of insulation in a wood frame assembly. This minimum level is typically superseded by requirements of the compliance approach. The insulation may be of greater insulating value in certain areas of the ceiling and of lesser insulating value in other areas of the ceiling provided the overall weighted average U-value does not exceed the equivalent R-19 framed value (maximum U-value less than or equal to 0.051) as documented on a Form 3R, explained in Appendix G, *Glossary*, *R-Value*.

Insulation not penetrated by framing, such as rigid insulation, can comply with this insulation requirement if the assembly U-value is less than or equal to 0.051. Compliance can be documented with a Form 3R.

Metal or steel frame assemblies cannot use a Form 3R but have several options available. Use precalculated U-values from Appendix G, precalculated metal frame assemblies from Appendix I, calculate the assembly U-values using form ENV-3 for metal frame assemblies (see Appendix I), or use EZFRAME (see Appendix E) or another method based on the ASHRAE zonal method (1993 *ASHRAE Handbook of Fundamentals*).

Insulation must be certified in compliance with Section 118 (see page 2-3). Ceiling insulation should extend far enough to the outside walls to cover the top plate. However, insulation should not block eave vents in attics because if the flow of air is blocked, water vapor may condense on the underside of the roof, reducing the insulation's effectiveness and possibly cause structural damage. (See Figures 2-2 and 2-3.)

Where a roof slopes down, insulation may be tapered at the wall. An elevated truss or similar treatment is not needed for full insulation depth at the outside of the wall, but may be desirable. If insulation is tapered for more than three feet from the outside wall, this must be reflected in a weighted average U-value calculation for the ceiling assembly as shown in the compliance documentation.

Ceiling insulation levels should correspond to levels specified on the CF-1R and IC-1 (insulation certificate) forms. Although R-19 between wood framing is the minimum mandatory level for ceiling insulation between wood framing members, the package or performance requirement may establish a higher level.

Fiberglass insulation levels are labeled on the insulation face and should be verified against the levels required by the CF-1R.

Clearances: Incandescent recessed fixtures must be approved for zero-clearance insulation cover (IC-rated). Alternatively, a box built over a recessed fixture to provide clearance between the fixture and the insulation is acceptable. Insulation clearances from appliances should meet manufacturer specifications and local code restrictions should be verified.

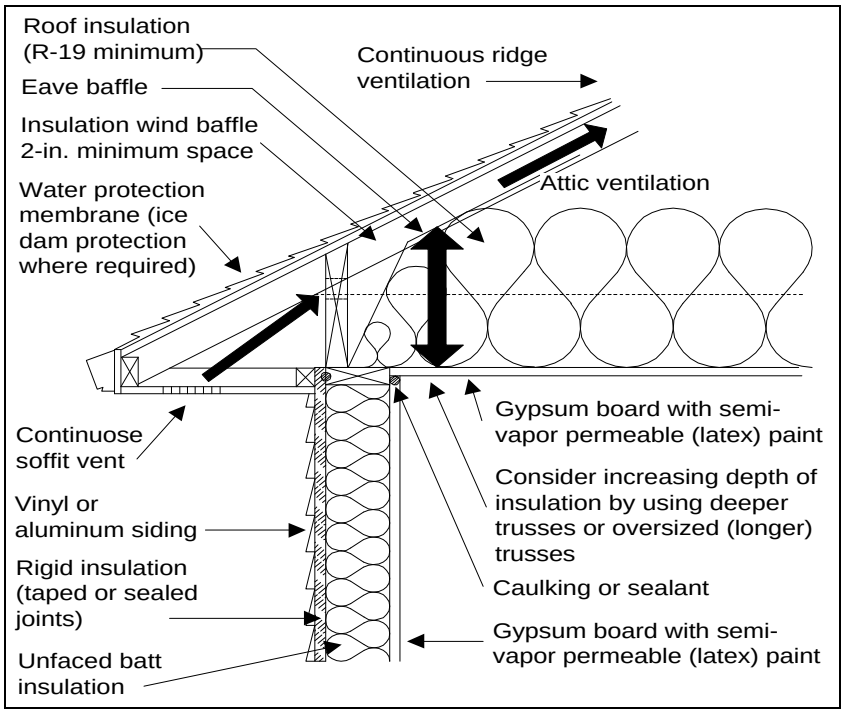


Figure 2-2: Ceiling Insulation Construction Detail

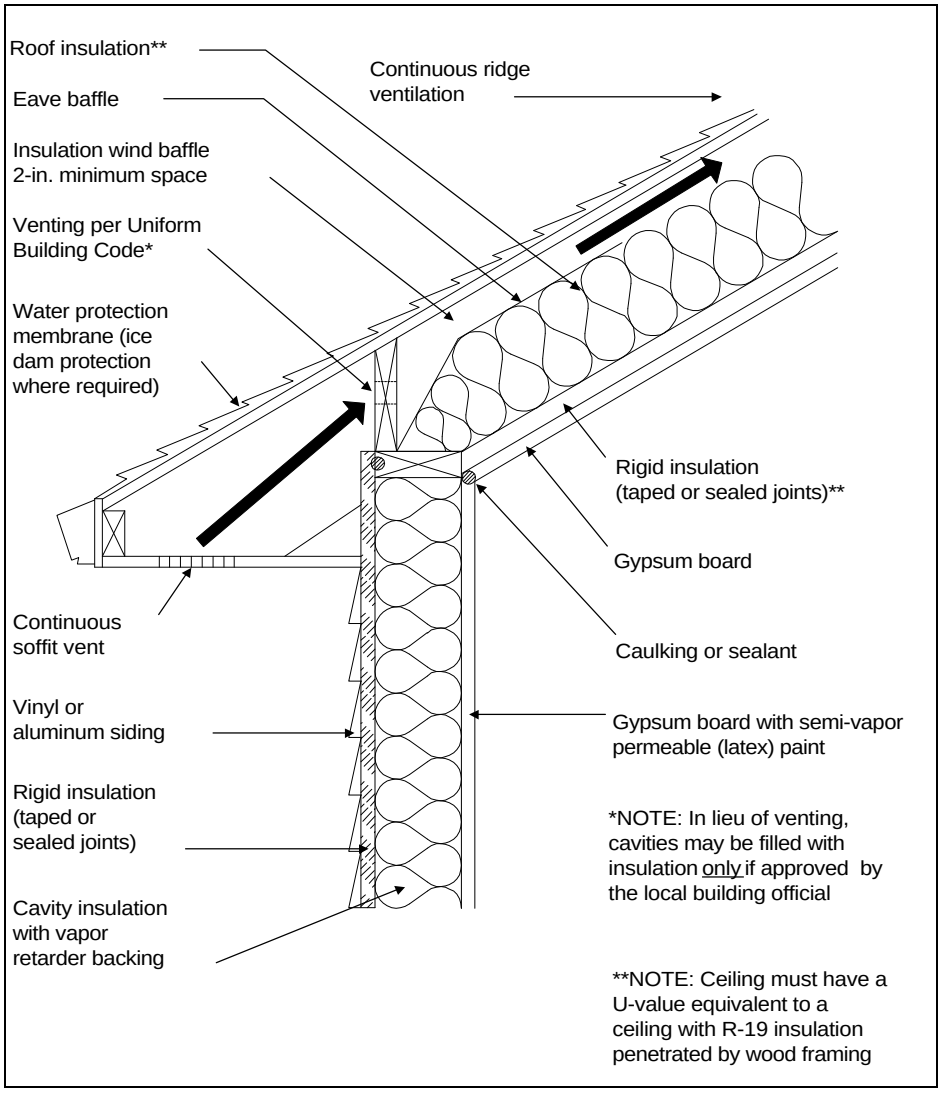


Figure 2-3: Cathedral Ceiling

Where ceiling insulation is installed next to eave or soffit vents, a rigid baffle should be installed at the top plate to direct ventilation air up and over the ceiling insulation. The baffle should extend beyond the height of the ceiling insulation and should have sufficient clearance between the baffle and roof deck at the top (see Figures 2-2 and 2-3).

Loose fill insulation should be blown in evenly and insulation levels can be verified by checking that the depth of insulation conforms to the manufacturer's coverage chart for the listed R-value. Additionally, three criteria the installer must consider are: 1) roof slope, 2) ceiling slope and 3) clearance. The installer should follow the guidelines shown in the construction portion for loose fill insulation (see below).

Incandescent recessed fixtures must be approved for a zero-clearance insulation cover. Insulation clearances from appliances should meet manufacturer specifications and local code restrictions should be verified.

The Insulation Certificate (IC-1) must be completed and signed by the insulation contractor or general contractor. This form is either posted at the job site or made available during inspection and when completed, a copy of this form must be provided to the first occupant of the building.

Examples

Ceiling Insulation

Example 2-1

A computer method analysis shows that a new house requires R-30 ceiling insulation to comply using the performance approach, but the minimum mandatory insulation level for ceiling insulation is only R-19. The higher insulation level must be installed for the building to comply.

Example 2-2

A small addition to an existing house appears to comply with only R-15 ceiling insulation using a performance approach. However, R-15 would not be sufficient because the required minimum ceiling insulation level established by the mandatory measures is R-19.

Energy Code

Loose Fill Insulation (Section 150(b))

(b) ***Loose Fill Insulation.*** *When loose fill insulation is installed, the minimum installed weight per square foot shall conform with the insulation manufacturer's installed design weight per square foot at the manufacturer's labeled R-value.*

Construction

Loose Fill Insulation

When loose fill insulation is installed, it should be blown in evenly. The minimum installed weight per square foot and the minimum depth must conform to the insulation manufacturer's coverage chart for the listed R-value. Three criteria to consider are: (1) roof slope, (2) ceiling slope, and (3) clearance (all criteria are recommendations to ensure even distribution and that insulation installed on a sloped surface does not settle to the extent that it becomes ineffective as a barrier between the conditioned and unconditioned space):

1. For a fairly typical situation where the ceiling is flat and the roof is sloped, the recommendation is that the roof slope be at minimum a 2-1/2 foot rise in a 12-foot run. This is to allow enough room between the ceiling and roof for sufficient insulation thickness.

2. If the ceiling is sloped, loose fill can be used if the slope is no more than a six foot rise in a 12 foot run and manufacturer's restrictions are not exceeded. If, however, the ceiling slope is steep (greater than six feet in 12 feet), loose fill insulation should not be used unless it incorporates non-water soluble adhesive binder.

3. The recommendation of a 30 inch clearance, from the top of the bottom chord of the truss or ceiling joists to the underside of the roof sheathing, is to facilitate installation and inspection.

When eave vents are installed, adequate baffling of vent openings shall be provided to deflect the incoming air above the surface of the material and shall be installed at the soffit. Baffles shall be in place at the time of framing inspection.

Inspection

Loose Fill Insulation

Follow the above guidelines when inspecting loose fill insulation to ensure adequate coverage, baffling at eave vents and installation in accordance with manufacturer specifications.

Energy Code

Wall Insulation (Section 150(c))

(c) ***Wall Insulation.*** *The opaque portions of frame walls separating conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of either 1 or 2 below:*

1. Wood framed walls shall be insulated between framing members with insulation having an installed thermal resistance of R-13 or greater. Framed foundation walls of heated basements or heated crawl spaces shall be insulated above the adjacent outside ground line with insulation having an installed thermal resistance of at least R-13.

ALTERNATIVE to Section 150(c)1.: Insulation which is not penetrated by framing members may meet an R-value

equivalent to installing R-13 insulation between wood framing members and accounting for the thermal effects of framing members.

2. *The weighted average U-value of walls shall not exceed the U-value that would result from installing R-13 insulation between wood framing members and accounting for the effects of framing members.*

Compliance/ Plan Check

Wall Insulation

Compliance for wood frame walls can be met by specifying at least R-13 insulation between framing members (the compliance approach may require a higher level). A U-value can be determined by using standard values from Appendix G, Table G-14 (no Form 3R is required when these values are used). Appendix I contains pre-calculated Form 3Rs for assemblies with rigid insulation (a copy of the form may be submitted with compliance documentation). An assembly U-value may also be calculated using the directions for completing a Form 3R (see Appendix G).

Metal or steel frame assemblies cannot use a Form 3R but have several other options. Use precalculated values from Appendix G, precalculated metal frame assemblies from Appendix I, calculate the assembly U-values using form ENV-3 for metal frame assemblies (see Appendix I), or use EZFRAME or another method based on the ASHRAE zonal method (1993 *ASHRAE Handbook of Fundamentals*).

Walls that have no framing, such as masonry or concrete exterior walls, do not have to be insulated with R-13 insulation (see Figure 2-4A), but will have to meet the minimum heavy or light mass requirements if using a prescriptive approach.

Framed foundation walls of heated basements or heated crawl spaces must be insulated above the adjacent outside ground line with at least R-13 insulation. Also, alternative component package D in Climate Zone 16 requires R-13 insulation on below grade concrete walls (see Chapter 3).

Insulation not penetrated by framing members, such as rigid insulation over the face of framing, may meet an R-value equivalent to a wall with R-13 insulation adjusted for the effects of wood framing 16" o.c. (maximum U-value 0.088). Documenting equivalency for a wall assembly may also be shown on the Form-3R (see G*lossary, R-Value)*.

Insulation may be of greater insulating value in certain areas of the wall and of lesser insulating value in other areas of the wall provided that the overall weighted average U-value does not exceed the equivalent R-13 framed value (maximum U-value less than or equal to 0.088).

As an alternative, U-values for concrete and masonry walls can be determined using the simplified masonry calculation method and Form 3R (see Appendix H).

NOTE:

An existing structure, such as a garage, with R-11 framed walls that is showing compliance with a performance approach, need not comply with the mandatory R-13 wall insulation. The addition must achieve compliance under an energy budget approach with R-11 insulation in these walls.

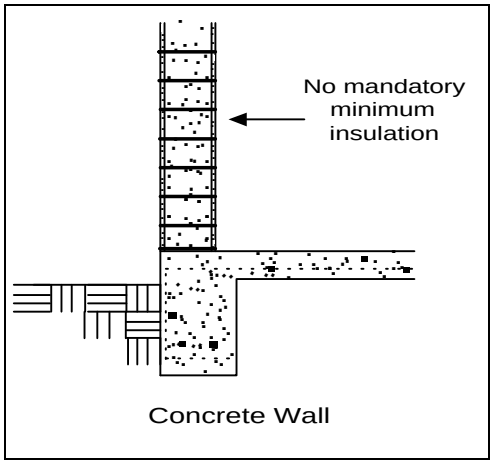


Figure 2-4A: Concrete Wall Insulation

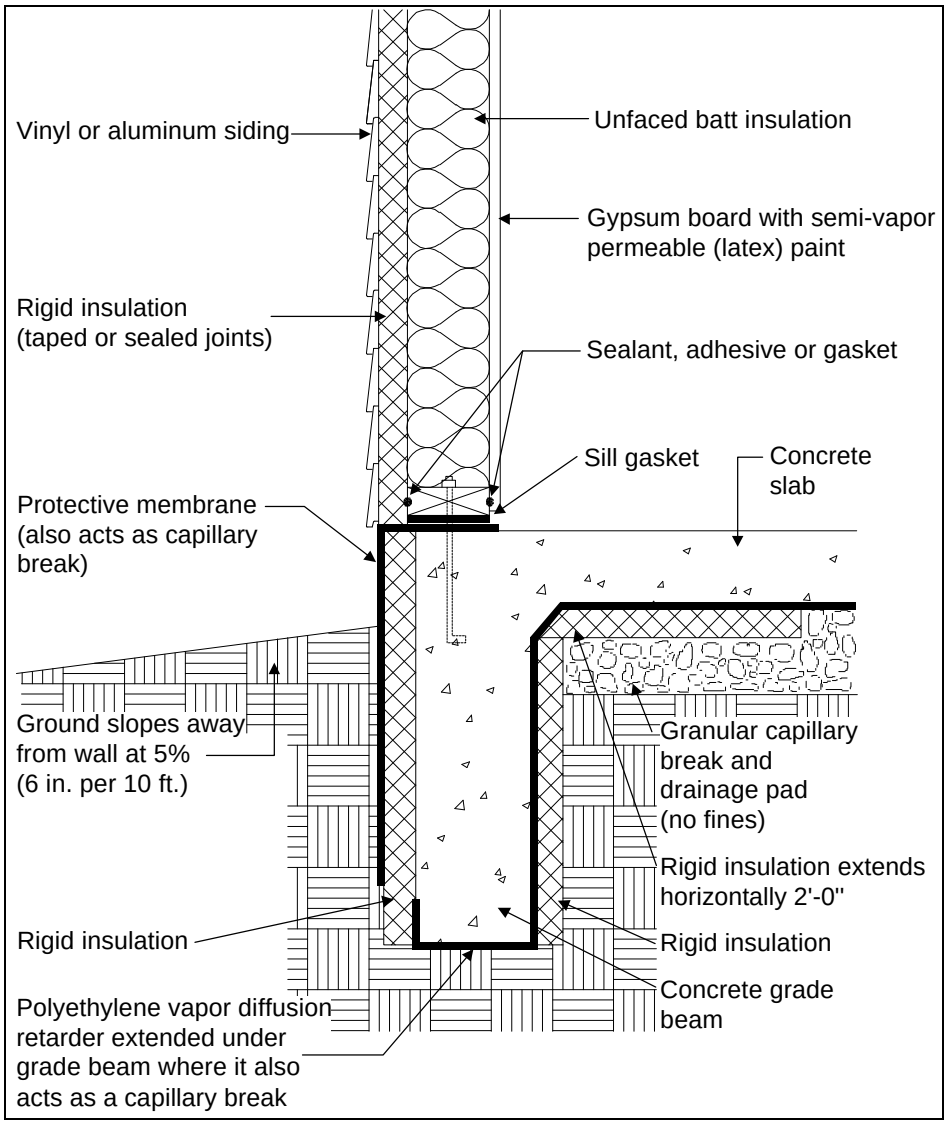


Figure 2-4B: Construction Details, Wood-Framed Wall with Vinyl or Aluminum Siding, Mandatory Minimum R-13 Insulation or U-value ≤ 0.088


Construction

Wall Insulation

A change from wood framing to metal framing can significantly affect compliance. These two framing types are not interchangeable. Metal frame wall construction requires rigid insulation in order to meet the mandatory minimum wall insulation level (U-value less than or equal to 0.088), Therefore, if compliance calculations indicate wood frame construction, either the compliance calculations must be redone with the correct assembly, or a metal frame construction with an equivalent U-value is required (R-5 rigid insulation with R-15 batt in 2x4 metal framing, 24” o.c.; R-4 rigid insulation with R-19 batt in a 2x6, 24” o.c.).

Rim joists between the stories of a multi-story building are part of the wall and must be insulated to the same level as the wall.

Wall insulation levels should correspond to levels specified on the CF-1R and IC-1 (Insulation Certificate) forms.

R-13 between wood framing is the minimum mandatory requirement; the package or performance requirement may establish a higher level. This requirement can be met with R-13 cavity insulation in a wood framed wall or with a weighted average U-value that is equivalent (maximum U-value 0.088).

Metal framed walls will require rigid insulation to achieve the maximum 0.088 U-value.

Walls that have no framing, such as masonry or concrete, are not required to meet this minimum requirement but may have other insulation requirements as indicated on the CF-1R.

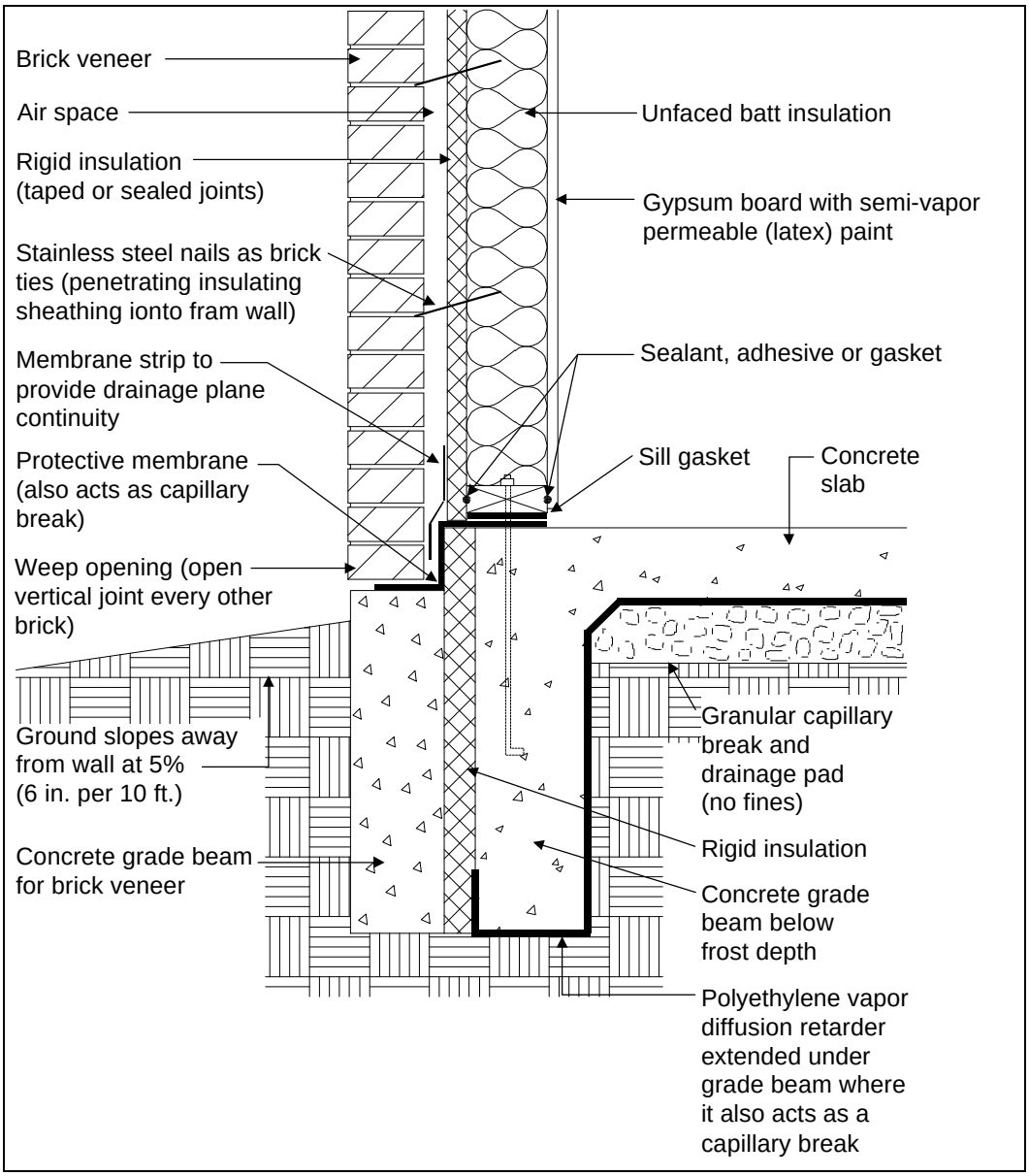


Figure 2-4C: Construction Details, Wood-Framed Wall with Brick Veneer, Mandatory Minimum R-13 Insulation or U-value ≤ 0.088

The Insulation Certificate (IC-1) must also be completed, signed by the insulation contractor or general contractor. The insulation levels, including rigid insulation, must be consistent with information on the CF-1R. This form is either posted at the job site or made available during inspection and when completed, a copy of this form must be provided to the first occupant of the building.

The R-value of different types of rigid insulation can vary significantly. If rigid insulation is specified on the plans, verify that the type installed is consistent with those specifications.

Because it is difficult to inspect wall insulation between tub/shower enclosures after the enclosure is installed, insulation of these wall sections should be inspected during the framing inspection.

Batt insulation should fill the wall cavity evenly and the kraft facing should be installed per manufacturer recommendations to minimize air leakage and avoid sagging in the insulation.

Wall insulation should extend into the perimeter floor joist (rim joist) cavities along the same plane as the wall.

If a vapor barrier is required, it must face the conditioned space on all installations.


Examples

Wall Insulation

Do new residential buildings or additions consisting of block walls (for example, converting a garage into living space) have to comply with the R-13 minimum wall insulation requirement? If not, what insulation R-value do they need?

No, the mandatory wall insulation requirement for R-13 applies to frame walls only. The amount of insulation needed, if any, will vary depending on the compliance approach selected. Performance compliance (computer) with the standards may not require any additional insulation if the overall compliance is achieved without insulation in that space. Prescriptive compliance may require some level of insulation, depending on the climate zone, package selected, and whether the walls are light (block) or heavy mass. Use *Residential Manual* Appendix B, Materials Reference, to determine the R-value of the mass wall alone. If additional insulation is required, it must be integral with the wall or installed on the outside of the mass wall (*Energy Efficiency Standards*, Section 151(f), Tables No. 1-Z1 through 1-Z16, Note 2).

If I build a steel framed wall with R-13 insulation between the framing, does this comply with mandatory wall insulation requirements?

No. The wall must have the equivalent U-value as a wood framed wall with R-13 insulation, which is 0.088 U-value or better (lower) (Section 150(c)2). To determine if a steel frame assembly meets this U-value, you have several options.

- Use one of the pre-calculated assemblies found in Appendix I of the *Residential Manual*.
- Calculate the U-value using an ENV-3 for steel frame construction (from Appendix I or from the *Nonresidential Manual*.
- Calculate the U-value using EZFRAME or another method based on ASHRAE zone method.

You *cannot* use any of the following to document the U-value of a steel frame wall:

- Form 3R or any parallel path method,
- values from Chapter 4, Table 4-4, in the *Residential Manual* which exceed 0.088 U-value, or
- any U-value which is more than 10 percent different than values found in or calculated using one of the above referenced sources.


Energy Code

Raised Floor Insulation (Section 150(d))

(d) ***Raised Floor Insulation.*** *Raised floors separating conditioned space from unconditioned space shall meet the requirements of either 1 or 2 below:*

1. *Floors shall be insulated between wood framing members with insulation having an installed thermal resistance of R-13 or greater.*

2. *The weighted average U-value of floor assemblies shall not exceed the U-value that would result from installing R-13 insulation between wood framing members and accounting for the effects of framing members.*

ALTERNATIVE to Section 150(d) 1. and 2.: Raised floor insulation may be omitted if the foundation walls are insulated to meet the wall insulation minimums shown in Tables No. 1-Z1 through 1-Z16, a vapor barrier is placed over the entire floor of the crawl space, and vents are fitted with automatically operated louvers that are temperature actuated.

Compliance/ Plan Check

Raised Floor Insulation

The raised floor insulation may be of greater insulating value in some areas and of lesser insulating value in other areas of the raised floor, provided the overall weighted average U-value does not exceed the equivalent R-13 framed value (maximum U-value less than or equal to 0.064).

Insulation that is not penetrated by framing members, such as rigid insulation over the face of framing, may meet a U-value equivalent to a wood framed floor with R-13 insulation adjusted for the effects of wood framing (U-value less than or equal to 0.064). Documenting equivalence may also be shown using Form-3R (see *Glossary*, *R-Value)*.

NOTE:

The approved computer methods (see Chapter 4) provide a thermal credit equivalent to R-6 insulation in raised floors over crawl spaces. The maximum raised floor U-value of 0.064 cannot be met by including the effects of the R-6 crawl space.

NOTE:

An alternative to meeting the minimum raised floor insulation level is to meet all criteria of *Controlled Ventilation Crawl Spaces* described in the Chapter 7, Part 7.7. If all eligibility and installation criteria for a controlled ventilated crawl space are met, raised floors above the controlled ventilation crawl space need not meet the minimum insulation requirement.

Inspection

Raised Floor Insulation

If the building has a wood raised floor, a minimum of R-13 insulation is required (see Figure 2-5). Check the CF-1R for the required insulation level.

The IC-1 must be completed and signed by the installing contractor or the project's general contractor. The insulation levels specified on both forms must be consistent.

For proper installation, floor insulation should be installed flush against the subfloor, stapled to the floor joists and supported with netting stapled to the underside of floor joists, or supported with wires running perpendicular to the joists. Floor insulation should not cover foundation vents.

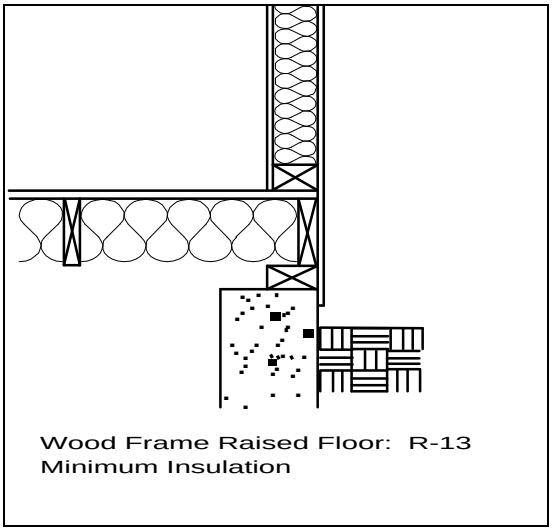


Figure 2-5: Raised Floor Insulation

Energy Code

Slab Edge Insulation (Section 150(l))

(l) ***Slab Edge Insulation.*** *Material used for slab edge insulation shall meet the following minimum specifications:*

1. *Water absorption rate no greater than 0.3 percent when tested in accordance with ASTM-C-271-94.*

2. *Water vapor permeance no greater than 2.0 perm/inch when tested in accordance with ASTM-E-96-95.*

2. *Concrete slab perimeter insulation must be protected from physical damage and ultra violet light deterioration.*

Slab Edge Insulation

Compliance/
Plan Check

Slab edge insulation is not a mandatory requirement for typical slab-on-grade construction, however, it may be required by the prescriptive package (see Chapter 3), or used for credit in the compliance calculations.

Slab edge insulation (R-10) is mandatory with hydronic heating systems with the distribution piping in the slab. As with other mandatory requirements, it is not modeled or assumed as part of the compliance calculations.

Construction

Slab Edge Insulation

Slab edge insulation reduces heat loss through the slab perimeter. When required, as indicated on the CF-1R, the material used must meet the above specifications.

An example of an insulating material that meets these specifications is smooth-skin extruded polystyrene.

See Figure 2-6 and Chapter 3 for installation criteria.

Slab Edge Insulation

Inspection

If slab edge insulation is indicated on the CF-1R, it is inspected during the foundation inspection. The IC-1 must also be completed and signed by the installing contractor or the project's general contractor. The insulation levels specified on both forms must be consistent.

The R-value and water absorption/permeance properties should be stamped on the insulation, or the installing contractor should provide manufacturer's literature to verify these requirements

The slab edge must be protected from physical damage and ultra-violet light deterioration when installed on the exterior footing. Slab edge is not required around the garage, between the house and the porch, or between the garage and the house.

Slab edge insulation is not required around the garage, between the house and the porch, or between the garage and the house.

NOTE:

In a building with a hydronic radiant slab floor heating system, R-10 slab edge insulation must be installed.

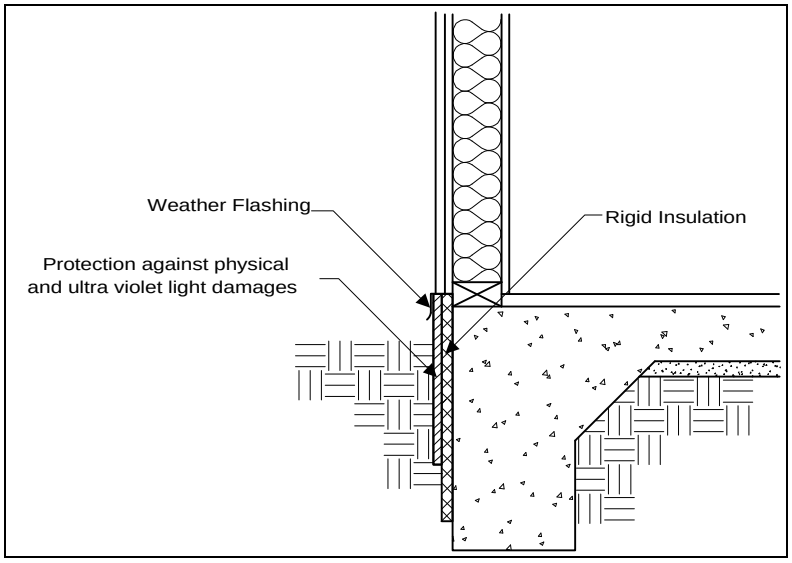


Figure 2-6: Slab Edge Insulation

Examples

Slab Edge Insulation

What are the slab edge insulation requirements for a hydronic heating system with the hot water pipes in the slab?

The requirements for slab edge insulation can be found in *Energy Efficiency Standards*, Sections 150(l) and 151(f)1., as described and in Chapter 3, and 3.2 of this manual.

Material and installation specifications:

- R-10 installed to a depth of 16 inches or to the depth of the footing, whichever is less,
- protected from physical damage and ultraviolet light deterioration,
- water absorption rate no greater than 0.3 percent (ASTM-C-271), and
- water vapor permeance no greater than 2.0 per/inch (ASTM-E-96-90).

Modeling assumptions:

- Do not model or calculate R-10 insulation; it is a mandatory requirement for this type of heating system. Instead assume R-0 in climate zones 1-15 or R-7 in climate zone 16.

Energy Code

Insulation in Existing Buildings (Section 118(d))

(d) ***Installation of Insulation in Existing Buildings****. Insulation installed in an existing attic, or on an existing duct or water heater, shall comply with the applicable requirements of this subsection. If a contractor installs the insulation, the contractor shall certify to the customer, in writing, that the insulation meets the applicable requirements of this subsection.*

1. ***Attics****. If insulation is installed in the existing attic of a low-rise residential building, the R-value of the total amount of insulation (after addition of insulation to the amount, if any, already in the attic) shall be at least R-30, if the building is located in an area that has less than 5,000 heating degree days, or R-38 if the building is located in an area that has 5,000 heating degree days or more.*

EXCEPTION to Section 118(d)1.: Where the accessible space in the attic is not large enough to accommodate the required R-value, the entire accessible space shall be filled with insulation provided such installation does not violate Section 1505.3 of Title 24, Part 2.

2. Water Heaters. If external insulation is installed on an existing unfired water storage tank or on an existing back up tank for a solar water heating systems, it shall have an R-value of at least R-12, or the heat loss of the tank surface based on an 80°F water-air temperature difference shall be less than 6.5 Btus per hour per square foot.

3. Ducts. If insulation is installed on an existing space conditioning duct, it shall comply with Section 604 of the UMC.

Compliance/ Plan Check

Insulation in Existing Buildings

EXISTING ATTIC

When insulation is being installed in an existing, accessible attic it must meet or exceed:

- **R-30** if the building is located in an area that has less than 5,000 heating degree days; or
- **R-38** if the building is located in an area that has 5,000 heating degree days or more.

Heating degree days for 641 California locations can be found in Appendix C.

EXISTING STORAGE TANKS

There are no requirements for typical storage water heaters. If a permit applicant is adding insulation to an unfired water heater (e.g., holding tank for a boiler) or an existing back-up tank for a solar water heating system, at least R-12 must be added.

EXISTING DUCT SYSTEM

When a permit applicant is adding insulation to an existing duct system, R-4.2 insulation is required, unless cooling system ducts are installed on the roof or heating system ducts are installed on the roof in an area with more than 8,000 heating degree days where a minimum of R-6.3 insulation is required by the UMC. Heating degree days for 641 California locations can be found in Appendix C. See Part 2.4 for installation guidelines.

Inspection

Insulation in Existing Buildings

Installation of ceiling insulation should match guidelines contained in discussions under “ceiling insulation,” “loose fill insulation” and “certified insulating materials” in this chapter.

An Insulation Certificate (IC-1) must be completed, signed by the insulation contractor or general contractor. This form can either be posted at the job site or given to the building owner.

Energy Code

Fenestration Products and Exterior Doors (Section 116, 101(b)

(a) ***Certification of Fenestration Products and Exterior Doors.*** *Any fenestration product and exterior door, other than field-fabricated fenestration products and field-fabricated exterior doors, may be installed only if the manufacturer has certified to the Commission, or if an independent certifying organization approved by the Commission has certified, that the product complies with all of the applicable requirements of this subsection.*

1. ***Air Leakage.*** *Manufactured fenestration products and exterior doors shall have air infiltration rates not exceeding 0.3 cfm/ft² of window area, 0.3 cfm/ft² of door area for residential doors, 0.3 cfm/ft² of door area for nonresidential single doors (swinging and sliding), and 1.0 cfm/ft² for nonresidential double doors (swinging), when tested according to NFRC-400-95 or ASTM E283-91 at a pressure differential of 75 pascals or 1.57 pounds/ft², incorporated herein by reference.*

2. ***U-value and SHGC.*** *Fenestration products shall:*

   A. *Be certified for overall U-values as rated in accordance with the National Fenestration Rating Council's NFRC-100-91 (1991), or NFRC 100 (1997) and be certified for overall SHGC, as rated in accordance with the National Fenestration Rating Council's NFRC 200 (1995), incorporated herein by reference, or such values shall be certified in accordance with a default table method set forth in Section 10-111; and*

   B. *Have a temporary label meeting the requirements of Section 10-111(a)(1), not to be removed before inspection by the enforcement agency, listing the certified U-value and SHGC, and certifying that the air infiltration requirements of Section 116(a)1. are met for each product line; and*

   C. *Have a permanent label meeting the requirements of Section 10-111(a)(2) if the product is rated using NFRC procedures.*

EXCEPTION to Section 116(a): Fenestration products removed and reinstalled as part of a building alteration or addition.

EXCEPTION to Section 116(a)2: Glazed wall systems and overhead glazing in buildings covered by the nonresidential standards shall have SHGC and U-values determined in accordance with NFRC procedures or default values set forth in Section 116(a)2.A. Temporary and permanent labels are not required.

(b) ***Installation of Field-Fabricated Fenestration Products and Exterior Doors.*** *Field-fabricated fenestration products and exterior doors shall be caulked between the fenestration products or exterior door and the building, and shall be weatherstripped.*

EXCEPTION to Section 116(b): Unframed glass doors and fire doors.

Table No. 1-D
DEFAULT FENESTRATION PRODUCT U-VALUES

Frame Type[1]	***Product Type***	***Single Pane U-value***	***Double Pane U-value[2]***
Metal	*Operable*	*1.28*	*0.87*
Metal	*Fixed*	*1.19*	*0.72*
Metal	*Greenhouse/Garden window*	*2.26*	*1.40*
Metal	*Doors*	*1.25*	*0.85*
Metal	*Skylight*	*1.72*	*0.94*
Metal, Thermal Break	*Operable*		*0.71*
Metal, Thermal Break	*Fixed*		*0.60*
Metal, Thermal Break	*Greenhouse/Garden window*		*1.12*
Metal, Thermal Break	*Doors*		*0.64*
Metal, Thermal Break	*Skylight*		*0.80*
Non-Metal	*Operable*	*0.99*	*0.60*
Non-Metal	*Fixed*	*1.04*	*0.57*
Non-Metal	*Doors*	*0.99*	*0.55*
Non-Metal	*Greenhouse/Garden windows*	*1.94*	*1.06*
Non-Metal	*Skylight*	*1.47*	*0.68*

[1] Metal includes any field-fabricated product with metal cladding. Non-metal framed manufactured fenestration products with metal cladding must add 0.04 to the listed U-value. Non-Metal frame types can include metal fasteners, hardware, and door thresholds. Thermal break product design characteristics are:

- *a. The material used as the thermal break must have a thermal conductivity of not more than 3.6 Btu-inch/hr/ft^2/°F,*
- *b. The thermal break must produce a gap of not less than 0.210", and*
- *c. All metal members of the fenestration product exposed to interior and exterior air must incorporate a thermal break meeting the criteria in (a) and (b) above.*

In addition, the fenestration product must be clearly labeled by the manufacturer that it qualifies as a thermally broken product in accordance with this standard.

[2]For all dual glazed fenestration products, adjust the listed U-values as follows:

- *a. Subtract 0.05 for spacers of 7/16" or wider.*
- *b. Subtract 0.05 for products certified by the manufacturer as low-E glazing.*
- *c. Add 0.05 for products with dividers between panes if spacer is less than 7/16" wide.*
- *d. Add 0.05 to any product with true divided lite (dividers through the panes).*

Table No. 1-E
DEFAULT SOLAR HEAT GAIN COEFFICIENT

			Total Window SHGC	
			Single	***Double***
Frame Type	***Product***	***Glazing***	***Pane***	***Pane***
Metal	*Operable*	*Uncoated*	*0.80*	*0.70*
Metal	*Fixed*	*Uncoated*	*0.83*	*0.73*
Metal	*Operable*	*Tinted*	*0.67*	*0.59*
Metal	*Fixed*	*Tinted*	*0.68*	*0.60*
Metal, Thermal Break	*Operable*	*Uncoated*	*0.72*	*0.63*
Metal, Thermal Break	*Fixed*	*Uncoated*	*0.78*	*0.69*
Metal, Thermal Break	*Operable*	*Tinted*	*0.60*	*0.53*
Metal, Thermal Break	*Fixed*	*Tinted*	*0.65*	*0.57*
Non-Metal	*Operable*	*Uncoated*	*0.74*	*0.65*
Non-Metal	*Fixed*	*Uncoated*	*0.76*	*0.67*
Non-Metal	*Operable*	*Tinted*	*0.60*	*0.53*
Non-Metal	*Fixed*	*Tinted*	*0.63*	*0.55*

SC = Shading Coefficient
SHGC = Solar Heat Gain Coefficient

Section 101(b):

DUAL-GLAZED GREENHOUSE WINDOWS are a type of dual-glazed fenestration product which adds conditioned volume but not conditioned floor area to a building.

EXTERIOR DOOR is a door through an exterior partition that is opaque or has a glazed area that is less than or equal to one-half of the door area. Doors with a glazed area of more than one-half of the door area are treated as a fenestration product.

FENESTRATION PRODUCT is any transparent or translucent material plus any sash, frame, mullions, and dividers, in the envelope of a building, including, but not limited to: windows, sliding glass doors, french doors, skylights, curtain walls, garden windows, and other doors with a glazed area of more than one-half of the door area.

FIELD-FABRICATED FENESTRATION PRODUCT OR EXTERIOR DOOR is a fenestration product or exterior door whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product or exterior door. Field fabricated does not include site assembled frame components that were manufactured elsewhere with the intention of being assembled on site (such as knocked down products, sunspace kits and curtainwalls).

SKYLIGHT is glazing having a slope less than 60 degrees from the horizontal with conditioned space below, except for purposes of complying with Section 151(f), where a skylight is glazing having a slope not exceeding 4.76 degrees (1:12) from the horizontal.

SKYLIGHT AREA is the area of the surface of a skylight, plus the area of the frame, sash, and mullions.

SOLAR HEAT GAIN COEFFICIENT (SHGC) is the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.

WINDOW is glazing that is not a skylight.

WINDOW AREA is the area of the surface of a window, plus the area of the frame, sash, and mullions.

Compliance/
Plan Check

Fenestration Products and
Exterior Doors

The National Fenestration Rating Council (NFRC) publishes the Certified Product Directory, containing NFRC certified U-Values and SHGC for thousands of products. The directory can be purchased by contacting:

NFRC
1300 Spring Street, Suite 120
Silver Springs, MD 20901
(301) 589-6372

Compliance calculations can use actual product data or default SHGC and U-values. Field-fabricated products should use default values.

Construction

Fenestration Products and
Exterior Doors

FIELD-FABRICATED PRODUCTS

Field-fabricated products are required to limit air leakage by weatherstripping, caulking, or some other appropriate means as described below in "Joints and Other Openings."

EXTERIOR DOORS

Exterior doors are required to meet the following requirements of the standards:

- Manufactured exterior doors must be certified as meeting an air leakage rate of 0.3 cfm/ft² of door area.
- Comply with the requirements of Section 117, as described below in "Joints and Other Openings."
- Any door with more than one half of the door area consisting of glass is a fenestration product.

MANUFACTURED FENESTRATION

Fenestration products must have a temporary label indicating the U-value and SHGC based on either the *CEC Default* or *NFRC Rating Procedures.* Only field-fabricated products are not required to be labeled.

Each manufactured fenestration product must:

- have a temporary label, not to be removed before inspection by the enforcement agency, listing the certified U-value, SHGC, and certifying that the requirements of air infiltration requirements of Section 116 are met (see Figure 2-7); and
- have a permanent label listing, the U-value, certifying organization, and rating procedures or a label to allow tracking back to the original certification information on file with the certifying organization.

Only field-fabricated products, as defined above, are exempt from the labeling requirements.

The U-value and SHGC values on the window label must be less than, or equal to, the values on the CF-1R. The CF-6R must be completed by the installer.

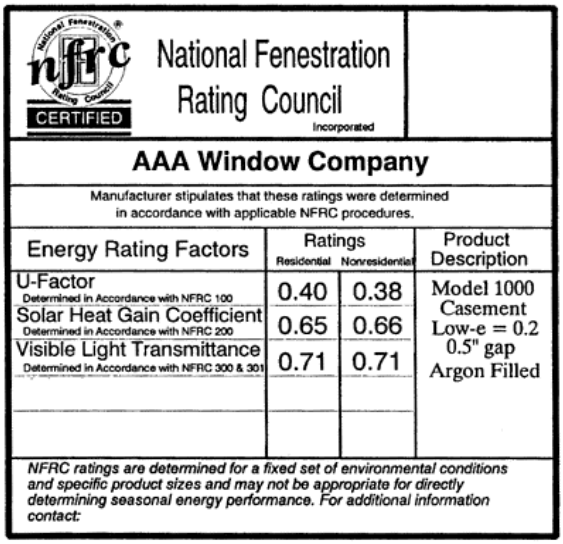
Inspection

Fenestration Products and
Exterior Doors

Fenestration and shading products play a major role in not only the building's energy use but can affect the operation of the HVAC system. Check the orientation and size of all installed fenestration including windows, doors with over one-half glass, and glazed skylights. Any increase in fenestration areas or changes in fenestration orientation can affect the energy compliance of a building and must be approved by the building plan checker. Homes in subdivisions are sometimes designed to allow for rotation in all four cardinal directions. However, this information needs to be verified on the CF-1R.

Check the CF-1R for any overhang requirement and refer to the plans for required dimensions.

Check the CF-6R completed by the installer and compare it to the temporary label. All fenestration products must have a temporary label indicating the U-value, Solar Heat Gain Coefficient (SHGC) and certification of air infiltration requirements (only field-fabricated products, as defined above, are exempt from labeling requirements).



National Fenestration Rating Council Incorporated

CERTIFIED

AAA Window Company

Manufacturer stipulates that these ratings were determined in accordance with applicable NFRC procedures.

Energy Rating Factors	Ratings Residential	Ratings Nonresidential	Product Description
U-Factor Determined in Accordance with NFRC 100	0.40	0.38	Model 1000 Casement Low-e = 0.2 0.5" gap Argon Filled
Solar Heat Gain Coefficient Determined in Accordance with NFRC 200	0.65	0.66	
Visible Light Transmittance Determined in Accordance with NFRC 300 & 301	0.71	0.71	

NFRC ratings are determined for a fixed set of environmental conditions and specific product sizes and may not be appropriate for directly determining seasonal energy performance. For additional information contact:

Figure 2-7: Temporary Label

The label may list two different sizes, "AA" (for residential) and "BB" (for nonresidential).

Values shown on the labels should be equal or lower than the values on the CF-1R, however, these values are often an average of the U-values and SHGCs that are to be installed. Compare the installed products to the CF-6R completed by the installer. The installer is responsible for ensuring compliance with the requirements of the CF-1R.

Examples

Fenestration Products and Exterior Doors

Can I use single-pane windows or skylights?

New buildings or additions using a *performance* approach (computer) may be able to achieve compliance with single-pane glass. How easy or difficult it is to make up the lost energy efficiency will depend on the climate zone and building design.

New buildings, additions or alterations showing compliance using *prescriptive* standards are limited to a maximum U-value for fenestration products which prevents the use of single pane glass.

My home will have a combination of fixed and operable windows. In determining the appropriate U-value for fenestration products, can I assume all windows are "fixed" in my compliance calculations?

You may assume the more conservative of the default values listed for fixed and operable windows. (Operable windows generally have a more conservative default value but this is not always the case with site built fenestration products.) Alternatively, you may calculate a weighted average U-value based on the actual condition of the windows. NOTE: Typical windows with a fixed portion and an operable portion are *operable*.

When modeling/accounting for greenhouse windows, which compliance approach allows the use of the "assumed" U-value of 0.75 for skylights and greenhouse windows? Do I use the entire glass area?

In prescriptive *additions* and *alterations* only, you can use a 0.75 U-value for dual-glazed greenhouse windows or skylights with any compliance method. In new construction, the actual U-value of fenestration products is used for compliance documentation/calculations. For greenhouse windows, the area of glass is considered to be the area of the rough opening.

When windows are labeled with a default value, are there any special requirements that apply to the label?

There are two criteria that apply to fenestration products labeled with default values. First, the *Administrative Regulations* (Section 10-111) require that the words "CEC Default U-Value" and "CEC Default SHGC" appear on the temporary label *in front of* or *before* the U-value or SHGC (i.e., not in a footnote). Second, the U-value and SHGC for the specific product must be listed. If multiple values are listed on the label, the manufacturer must identify, in a permanent manner, the appropriate value for the labeled product. Marking the correct value may be done in the *following ways only*:

- Circle the correct U-value and SHGC (*permanent ink*).
- Black out all values *except* the correct U-value and SHGC (*permanent ink*).
- Make a hole punch next to the appropriate values.

What U-value do I use for glass block? Does it need a label?

The default U-value for an unframed product is 0.57 (if the product is operable, the U-value is 0.60); for a product with metal framing the default U-value is 0.72 (if the product is operable, the U-value is 0.87).

A product label is required.

What solar heat gain coefficient do I use for glass block?

Either (1) use a default value from Table No. 1-E, for dual glazing with the appropriate frame type (for no frame use "non-metal"), or (2) obtain the manufacturer's published SHGC for the product.

Is there a default U-value for the glass in sunrooms?

For the horizontal portion of the sunroom, use the U-value for skylights. For the vertical portion, use the U-values for either fixed, operable or patio doors, as appropriate. Use either default or NFRC-rated U-values. As a simplifying alternative, the manufacturer may label the entire sunroom with the highest U-value of any of the individual fenestration types within the assembly.

How are French doors treated in compliance documentation, for example the U-value and dimensions?

French doors are fenestration products and are covered by the National Fenestration Rating Council (NFRC) Rating and Certification Program. You may use either an NFRC-rated U-value or a default (patio doors) U-value. The fenestration area for compliance documentation is the entire rough opening of the door (not just the glass area).

How can I determine a solar heat gain coefficient for French doors?

The solar heat gain coefficient (SHGC) for French doors may be determined in one of two ways:

1. Refer to Table 1-E. The SHGCs in this table have been pre-calculated based upon glazing type, framing type, and interior shade type.
2. Calculate the SHGC using a Solar Heat Gain Coefficient (SHGC) Worksheet (Form S). The Form S calculation allows the user to account for French doors with dividers and/or more than 50 percent glazing area.

As a manufacturer of fenestration products, I place a temporary label with the air infiltration rates on my products (Section 116(a)). Can you clarify which products must be tested and certified?

Each product line must be tested and certified for air infiltration rates. Features such as weather seal, frame design, operator type, and direction of operation all effect air leakage. Every product must have a temporary label certifying that the air infiltration requirements are met. This temporary label may be combined with the temporary U-value label.

Is a custom window "field-fabricated" for purposes of meeting air infiltration requirements?

No. Most custom windows are manufactured and delivered to the site either completely assembled or knocked down, which means they are a manufactured product. A window is considered field fabricated when the windows are assembled at the building site from the various elements *which are not sold together as a fenestration product* (i.e., glazing, framing and weatherstripping). As stated in the definition, "field fabricated does not include site assembled frame components that were manufactured elsewhere with the intention of being assembled on site (such as knocked down products, sunspace kits and curtainwalls)."

Energy Code

Joints and Other Openings (Section 117(a))

(a) Joints and other openings in the building envelope that are potential sources of air leakage shall be caulked, gasketed, weatherstripped, or otherwise sealed to limit infiltration and exfiltration.

Compliance/
Plan Check

Joints and Other Openings

Air leakage through cracks around windows, doors, walls, roofs and floors generally accounts for about one-third of the energy used for home heating and cooling. The standards contain a number of requirements to control infiltration and exfiltration.

Construction

Joints and Other Openings

The following openings in the building envelope must be caulked, gasketed, weather-stripped or otherwise sealed (see Figure 2-8):

- exterior joints around window and door frames, including doors between the house and garage, between interior HVAC closets and unconditioned space, between attic access and conditioned space, and between wall sole plates, floors, exterior panels and all siding materials;
- openings for plumbing, electricity, and gas lines in exterior walls, ceilings and floors;
- openings in the attic floor (such as where ceiling panels meet interior and exterior walls and masonry fireplaces); and
- all other such openings in the building envelope.

Alternative approved techniques may be used to meet the mandatory caulking requirements for exterior walls. These include, but are not limited to:

- continuous stucco
- caulking and taping all joints between wall components (e.g., between slats in wood slat walls)
- building wraps
- rigid wall insulation

Inspection

Joints and Other Openings

Openings in exterior walls are common to accommodate gas, plumbing or electrical lines. Any openings in the building envelope separating conditioned space from unconditioned space must be sealed to prevent air leakage. A proper seal can be verified by checking that the opening is continuously caulked all around and that no light can be seen around the opening. Caulking must also be applied between the bottom plate of the wall framing and the subfloor (see Figure 2-8).

Weather-stripping is required on all operable windows and doors. This includes doors between the garage and the house, between interior HVAC closets and conditioned space, and between the attic access and conditioned space.

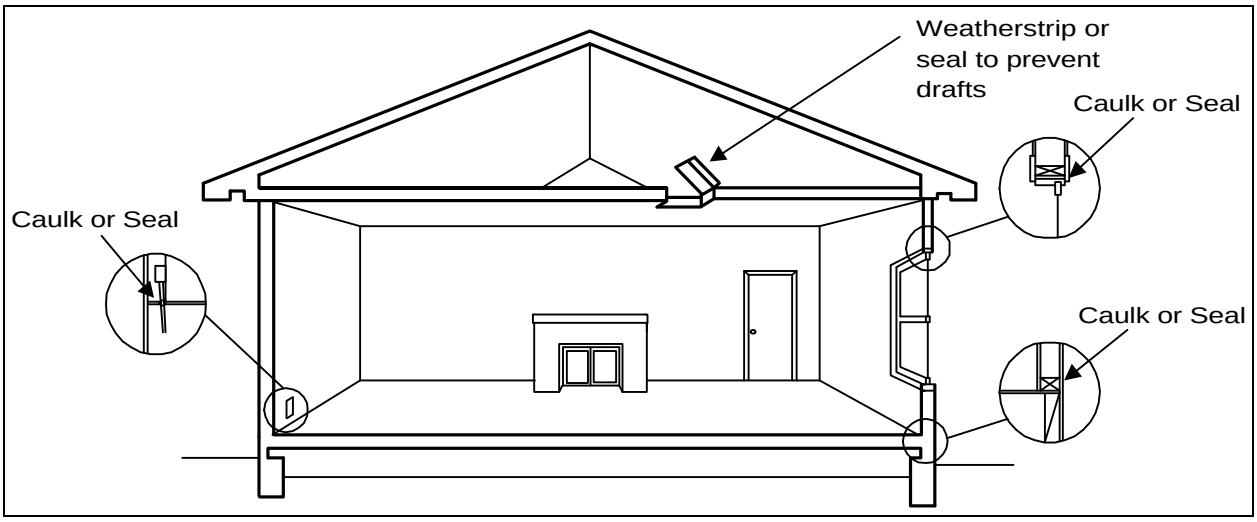


Figure 2-8: Caulking and Weatherstripping

Energy Code

Vapor Barrier (Sections 150(g), 101(b))

(g) ***Vapor Barriers.*** *In Climate Zones 14 and 16 as shown in Figure No. 1-A, a vapor barrier shall be installed on the conditioned space side of all insulation in all exterior walls, unvented attics, and unvented crawl spaces to protect insulation from condensation.*

If a building has a controlled ventilation crawl space (CVC), a vapor barrier shall be placed over the earth floor of the crawl space to reduce moisture entry and protect insulation from condensation, as specified in the ALTERNATIVE to Section 150(d).

Section 101(b):

VAPOR BARRIER is a material that has a permeance of one perm or less and that provides resistance to the transmission of water vapor.

Introduction

Vapor Barrier/Vapor Retarder

A vapor barrier or retarder is a special covering over framing and insulation that protects the wall assembly components from possible damage due to moisture buildup. When moisture gravitates from inside the house toward the outdoors, if it condenses against the exterior wall and in the insulation, the insulation loses its effectiveness.

Construction

Vapor Barrier/Vapor Retarder

In Climate Zones 14 and 16 only, a continuous vapor barrier, lapped or joint sealed, must be installed on the conditioned space side of all insulation in all exterior walls, on the floors of unvented attics, and on floors over unvented crawl spaces to protect insulation from condensation. If a building has a controlled ventilation crawl space (see Chapter 7, Part 7.7), a vapor barrier shall be placed over the earth floor of the crawl space to reduce moisture entry and protect insulation from condensation.

The standards define a vapor barrier as material with a permeance of one perm or less, a measure of resistance to the transmission of water vapors. A perm is equal to one grain of water vapor transmitted per square foot per hour per inch of mercury pressure difference.

Products such as a continuous polyethylene sheet or wall board with foil backing may meet this requirement, as well as any other product that, according to the appropriate testing procedure, meets the vapor barrier permeance rating of one perm or less. Kraft paper backing on batt insulation may qualify if the paper backing meets the vapor barrier permeance rating, and is properly installed. For proper installation, the Kraft paper should be installed per manufacturer instructions.-

See also Special Infiltration Barrier below.

Inspection

Vapor Barrier/Vapor Retarder

If a building is being constructed in climate zone 14 or 16, a continuous vapor barrier is required. One of several products should be indicated on the plans to comply with this requirement. Acceptable products include:

- Continuous polyethylene sheet,
- Wall board with foil backing,
- Kraft facing, or
- Any product that has appropriate test results verifying the permeance of one perm or less.

Kraft paper backing on batt insulation, under certain circumstances, may be used to meet the continuous vapor barrier requirement. Specifically, the paper backing must meet the vapor barrier permeance rating and the product must be installed properly.

For proper installation of batt insulation with Kraft paper backing:

1. Kraft paper should *not* be stapled to the sides of framing members; instead, the Kraft paper tabs on each side of the insulation batt must be fastened to the face of the conditioned side of the framing member, and

2. At the ends of the insulated cavity, the Kraft paper must overlap the framing members to create a continuous barrier at the wall cavity.

Energy Code

Special Infiltration Barrier (Section 150(f), 151(f)5.)

Infiltration Barrier. If an infiltration barrier is installed to meet the requirements of Section 151, it must have an air porosity of less than 5 ft³ per hour per square foot per inch of mercury pressure difference when tested in accordance with the requirements of ASTM E283-91. If a vapor barrier functions as an infiltration barrier it shall be located on the conditioned side of the exterior framing.

Section 151(f)5.:

Continuous Infiltration Barrier. Continuous infiltration barriers required in Tables No. 1-Z1 through 1-Z16 shall be installed over the inside face of framing in ceilings and over the inside or outside face of framing in exterior walls. Where ceilings are plank and beam construction exposed to the conditioned space, the barrier shall be placed on top of the planking, and the wall/ceiling joints shall be sealed with caulking or sealant. All openings in the building envelope for plumbing, electrical conduits and boxes, gas lines and valves, luminaires, ducts, flues and other elements which penetrate the infiltration barrier, shall be sealed with permanent tape or sealant.

Compliance/ Plan Check

Special Infiltration Barrier

Special or continuous infiltration barriers are required only for compliance with Alternative Component Package B in Climate Zones 1, 14, 15 and 16.

There is a new compliance option for "air-retarding wraps" that allows an energy credit. See Chapter 8, Part 8.14 for installation criteria.

Construction

Special Infiltration Barrier

If the compliance approach chosen requires a continuous infiltration barrier on ceilings and walls, that infiltration barrier must have an *air porosity* of less than 5 cubic feet per hour per square foot per inch of mercury pressure difference when tested in accordance with the requirements of the American Society of Testing and Materials ASTM E283-84.

If an infiltration barrier also functions as a vapor barrier (in Climate Zones 14 and 16), note that the material must meet the requirements of both a vapor barrier and infiltration barrier. The product shall be located on the inside of the wall framing or another approved location consistent with the testing of the product. (See also Chapter 8 for air-retarding wraps.)

Inspection

Special Infiltration Barrier

Special or continuous infiltration barriers are required only for compliance with Alternative Component Package B in Climate Zones 1, 14, 15 and 16 and will be indicated on the CF-1R and on the plans.

When required, the infiltration barrier must:

- be installed and ceilings and walls, and
- have an *air porosity* of less than 5 cubic feet per hour per square foot per inch of mercury pressure difference when tested in accordance with the requirements of the American Society of Testing and Materials ASTM E283-84.

If an infiltration barrier also functions as a vapor barrier (in Climate Zones 14 and 16), the material must meet the requirements of both a vapor barrier and infiltration barrier. The product shall be located on the inside of the wall framing or another approved location consistent with the testing of the product.

Energy Code

Fireplaces, Decorative Gas Appliances and Gas Logs (Section 150(e))

1. *If a masonry or factory-built fireplace is installed, it shall have the following:*

   A. *Closable metal or glass doors covering the entire opening of the firebox;*

   B. *A combustion air intake to draw air from the outside of the building directly into the firebox, which is at least 6-square inches in area and is equipped with a readily accessible, operable, and tight-fitting damper or combustion air control device; and*

   EXCEPTION to Section 150(e)1.B.: An outside combustion air intake is not required if the fireplace will be installed over concrete slab flooring and the fireplace will not be located on an exterior wall.

   C. *A flue damper with a readily accessible control.*

   EXCEPTION to Section 150(e)1.C.: When a gas log, log lighter, or decorative gas appliance is installed in a fireplace, the flue damper shall be blocked open if required by the manufacturer's installation instructions or the California Mechanical Code.

2. *Continuous burning pilot lights and the use of indoor air for cooling a firebox jacket, when that indoor air is vented to the outside of the building, are prohibited.*

Construction

Fireplaces, Decorative Gas Appliances and Gas Logs

Because conditioned air can escape through a fireplace chimney, fireplace efficiency can be greatly improved through proper air control which the standards require in the form of specific air control measures.

Installation of factory-built or masonry fireplaces (see Figure 2-9) must include:

- Doors covering the entire opening of the firebox that can be closed when the fire is burning.
- A combustion air intake that is at least 6 square inches equipped with a readily accessible, operable and tight-fitting damper.
- A flue damper with a readily accessible control.

These requirements do not apply to decorative gas appliances.

Two prohibitions for fireplaces, decorative gas appliances and gas logs are:

- continuously burning pilot lights in fireplaces, decorative gas appliances and gas logs; and
- indoor air vented to the outside to cool a firebox jacket.

NOTE:

If a gas log, log lighter, or decorative gas appliance is installed in a fireplace, the flue damper shall be blocked open per manufacturer's installation instructions or the Uniform Mechanical Code.

Inspection

Fireplaces, Decorative Gas Appliances and Gas Logs

Fireplace requirements:

- closable metal or glass doors;
- combustion air intake (six square inch) for all fireplaces over a raised floor;
- combustion air intake (six square inch) for all fireplaces on exterior walls of slab on grade floors (NOTE: The UMC requires outside combustion air for all buildings, see note above);

readily accessible flue damper control;

- no continuously burning pilot light; and
- no use of indoor air to cool firebox jacket.

NOTE:

When a gas log, log lighter or decorative gas appliance is installed in a fireplace, the flue damper shall be blocked open to the minimum amount required by the manufacturer's installation instructions or the Uniform Mechanical Code.

Decorative gas appliance requirements:

- no continuously burning pilot light; and
- no use of indoor air to cool firebox jacket

Gas log requirement:

- no continuously burning pilot light.

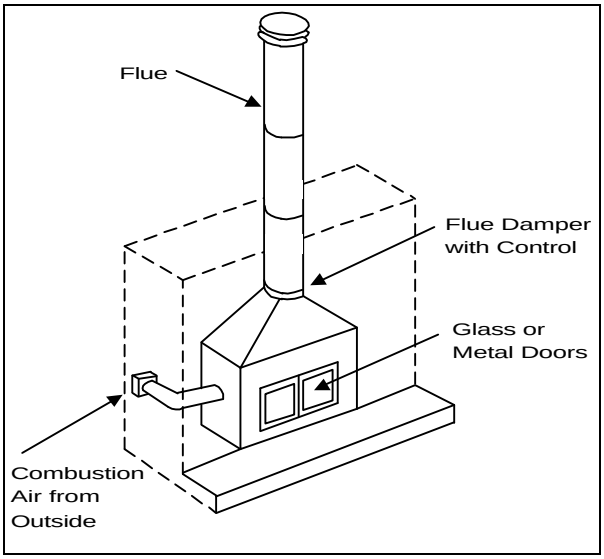


Figure 2-9: Fireplace Installation

Examples

Fireplaces, Decorative Gas Appliances and Gas Logs

Are closable glass or metal doors required for decorative gas appliances?

No. The only requirement of standards Section 150(e) that applies to decorative gas appliances is the prohibition on continuously burning pilot lights (Section 150(e)2). If there is a question about whether a device is a fireplace, which requires glass doors, the distinction is that a fireplace has a hearth, chamber or other place in which a solid fuel fire or a decorative gas log set may be burned, while a decorative gas appliance is for visual effect only and merely simulates a fire in a fireplace (Section 101.)

Although decorative gas appliances with continuously burning pilot lights are prohibited by the standards (Section 150(e)2), are they legal to sell in California?

Yes. These appliances can be sold for installation in existing residential buildings, hotels/motels, high-rise residential buildings and nonresidential buildings.

If I want to have a gas log or some other device in the fireplace of my home, can I block open the damper? Can it have a standing pilot light?

Section 150(e)1 (which contains the requirements for fireplaces, decorative gas appliances, and gas logs), allows the flue damper to be blocked open as required by either the manufacturer's instructions or the *Uniform Mechanical Code*. Continuously burning pilot lights in these appliances are prohibited by Section 150(e)2.

Section 150(e)2 of the standards states that no fireplace, decorative gas appliance or gas log can be installed if it has a continuously burning pilot light. The Uniform Mechanical Code requires all gas appliances installed in California have a manually operated shut-off valve, accessible to the inhabited space. Does this shut-off valve meet the intent of this section?

Not if the pilot light must be *manually extinguished* when the appliance is off. A unit that meets the intent of this section is one with a pilot light that *cannot* stay on when the unit is off.

Do decorative gas appliances need glass or metal doors?

As defined in Section 101 of the standards, decorative gas appliances do not need doors. The door requirement applies to masonry or factory-built fireplaces only (Section 150(e)1). NOTE: If a decorative gas appliance is installed *inside a fireplace*, the fireplace needs doors. Consult the manufacturer of the decorative gas appliance regarding combustion air requirements.

2.4 SPACE CONDITIONING, WATER HEATING AND PLUMBING SYSTEM MEASURES

The design and installation of a building's space-conditioning, water-heating and plumbing systems have a significant impact on the building's energy consumption. In view of this, the standards set a number of minimum requirements for these systems. The specific areas covered by the regulations include:

- HVAC equipment efficiency and certification,
- HVAC equipment controls,
- HVAC equipment sizing,
- duct construction,
- water heater and hot water pipe insulation,
- water heater and plumbing equipment efficiency and certification, and
- pool and spa heater efficiency.

The following section discusses each of the relevant mandatory measures in detail.

Energy Code

Systems and Equipment Certification, Appliance Efficiency Regulations (Sections 110-111)

Section 110: Systems and Equipment – General.

Sections 111 through 119 establish requirements for the manufacture, construction, and installation of certain systems, equipment, and building components that are installed in buildings regulated by Title 24, Part 6. Systems, equipment, and building components listed below may be installed only if:

(a) The manufacturer has certified that the system, equipment, or building component complies with the applicable manufacture provisions of Sections 111 through 119; and

(b) The system, equipment, or building component complies with the applicable installation provisions of Sections 111 through 119.

No system, equipment, or building component covered by the provisions of Section 111 through Section 119 that is not certified or that fails to comply with the applicable installation requirements may be installed in a building regulated by Title 24, Part 6.

The systems, equipment, and building components covered are:

Appliances regulated by the Appliance Efficiency Regulations. (Section 111)
Other space conditioning equipment. (Section 112)
Other service water heating systems and equipment. (Section 113)
Pool and spa heating systems and equipment. (Section 114)
Gas appliances. (Section 115)
Doors, windows, and fenestration products. (Section 116)
Joints and other openings. (Section 117)
Insulation. (Section 118)
Lighting control devices. (Section 119)

Section 111. Mandatory Requirements for Appliances Regulated by the Appliance Efficiency Regulations.

Any appliance for which there is a California standard established in the Appliance Efficiency Regulations may be installed only if the manufacturer has certified to the Commission, as specified in those regulations, that the appliance complies with the applicable standard for that appliance. See Appendix 1-A for availability of directories of certified appliances.

Only HVAC, water heating and plumbing system equipment certified by manufacturers as complying with applicable *Appliance Efficiency Regulations* at the time of manufacture may be installed. Equipment subject to certification may not be sold in California unless it is certified. This includes the following equipment types:

- Room air conditioners
- Room air conditioning heat pumps
- Central air conditioners with a cooling capacity of less than 135,000 Btu/hr
- Central air conditioning heat pumps
- Gas-fired central furnaces
- Gas-fired boilers
- Gas-fired furnaces
- Gas-fired floor furnaces
- Gas-fired room heaters
- Gas-fired duct furnaces
- Gas-fired unit heaters
- Gas water heaters
- Heat pump water heaters
- Electric storage water heaters
- Oil-fired water heaters
- Shower heads and faucets

A summary of appliance efficiency regulations for gas-fired space heaters, air conditioners and heat pumps is given under the definition of the efficiency descriptors in Appendix G, *Glossary*, under *AFUE, SEER* and *HSPF.*

The standards do *not* require certification for:

- Infrared heaters
- Nonstorage-type electric water heaters.
- Electric resistance heaters
- Oil-fired furnaces (some are voluntarily listed with certified gas-fired furnaces)

There are several sources of certification information for appliances (see Chapter 1, Part 1.6).

Federal appliance efficiency standards require that:

1. Gas fan type central furnaces with an input rate less than 225,000 Btu/hr and manufactured on or after January 1, 1992, must be certified by the manufacturer to have an Annual Fuel Utilization Efficiency (AFUE) of 78 percent or greater.

2. Boilers with an input rate less than 300,000 Btu/hr and manufactured on or after January 1, 1992, must be certified by the manufacturer to have an AFUE of 75 percent or greater for gas steam type boilers and 80 percent or greater for all other boilers.

3. Split system air source air conditioners or heat pumps with an output rate less than 65,000 Btu/hr and manufactured on or after January 1, 1992, must be certified by the manufacturer to have a Seasonal Energy Efficiency Ratio (SEER) of 10.0 or greater.

4. Single packaged air source air conditioners or heat pumps with an output rate less than 65,000 Btu/hr and manufactured on or after January 1, 1993, must be certified by the manufacturer to have an SEER of 9.7 or greater.

California efficiency requirements for larger capacity equipment than covered above are listed in Section 112 of the standards.

When an appliance is of a size or type not regulated by the Appliance Efficiency Regulations, it may be regulated by the standards (Section 112). Efficiency information for appliances not subject to certification can be obtained from the manufacturer, as listing such appliances with a certifying organizations is voluntary.

If any equipment does not meet the federal appliance efficiency standards, it may not be sold in California. Any equipment covered by the *Appliance Efficiency Regulations* and sold in California must have the date of manufacture permanently displayed in an accessible place on that equipment. This date is frequently included as part of the serial number.

NOTE:

Equipment manufactured before the effective date of a new standard may be sold and installed in California indefinitely, as long as a performance approach demonstrates compliance of the building (see Chapter 4) using the lower efficiency appliances.

Construction

Systems and Equipment

The person who signs off on the Installation Certificate (CF-6R) is required to certify that the actual equipment installed meets or exceeds the requirements of the *Appliance Efficiency Regulations* and that the equipment is equivalent to or more efficient than the equipment described on the Certificate of Compliance attached to the plans.

WATER HEATING

The number and types of water-heater systems installed must correspond to the approved CF-1R. The location of the water heater, adding a recirculating system, a hot water-recovery system are all factors of the distribution system and plays a significant role in water heating compliance. The distribution system must correspond to plan specifications.

The installation criteria for water heating distribution systems are described in Chapter 5, Table 5-1c.

FAUCETS AND SHOWER HEADS

Faucets and shower heads are limited by a federal standard to 2.5 gallons per minute. If equipped with a flow restrictor, it must be mechanically retained which means it requires eight pounds or more of pulling force to remove.

NOTE:

A reduced flow rate saves in two ways: (1) water-heating energy makes up about one-quarter of all energy in residences, so less water means less hot water; and (2) a 10 percent cut in water use means $100,000 in electricity savings from reduced pumping costs theoretically for one water district.

Inspection

Systems and Equipment

HEATING & AIR-CONDITIONING SYSTEMS

Verify the make and model number of the installed unit matches that listed on the Installation Certificate (CF-6R). For furnaces, the make and model number can be verified by removing the front plate and checking the nameplate data. For cooling units, the nameplate data is typically located on the unit's case (cowling).

The person who signs off on the Installation Certificate (CF-6R) is certifying that the actual equipment installed meets or exceeds the requirements of the *Appliance Efficiency Regulations* and that it is equivalent to, or more efficient than, the equipment described on the Certificate of Compliance attached to the plans. Compare the CF-6R data to the CF-1R data shown on the plans.

The equipment complies if, compared to what is shown on the CF-1R, it is of the same equipment type, equal or higher efficiency, same distribution type and location, has equal or higher duct (or piping) R-value and has a heating capacity greater than the heating load (to meet UBC requirements).

For cooling equipment sizing and equipment selection, the Mandatory Measures requirements for sizing and equipment selection should have been followed.

WATER HEATING

Check that the number and types of water-heater systems installed, as indicated on the CF-6R, and check to see that this corresponds to the approved CF-1R. The distribution system is also significant and must correspond to plan specifications. For example:

- If the plans indicate the presence of a hot water recovery system, it must be installed.
- If a recirculation system is installed, verify that it was accounted for in the compliance documentation (CF-1R) and check for any required controls (e.g., demand pump, timer).

- If a point of use credit is specified, the water heater must be no further than eight feet from all hot water outlets (excluding washing machines).

See Chapter 5, Part 5.1, for a summary of the different distribution system types and whether each one is a credit or a penalty as compared with the standard distribution system.

Verify that the make and model number of the installed water-heater unit matchthose listed on the Installation Certificate (CF-6R).

If the water heater has an energy factor (EF) of less than 0.58, an R-12 water-heater blanket is required (internal insulation cannot be used to satisfy this mandatory requirement). For water heaters with 0.58 EF or higher or large storage (typically commercial size) water heaters whose rated input is greater than 75,000 Btuh, that are not rated using an energy factor, no insulation blanket is required. The blanket should be securely attached around the water heater. The top of the water heater should not be insulated and a cutout in the blanket should be provided for combustion air intake.

FAUCETS AND SHOWER HEADS

Faucets and shower heads are limited by a federal standard to 2.5 gallons-per-minute. If equipped with a flow restrictor, it must be mechanically retained which means it requires eight pounds or more of pulling force to remove.

Energy Code

Space Conditioning Sizing (Section 150(h))

(h) ***Space Conditioning Sizing***

1. *Building design heat loss rate and design heat gain rate, shall be determined using a method based on any one of the following:*

   A. *The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Handbook and Product Directory, Equipment Volume (1996), HVAC Applications Volume (1995), and Fundamentals Volume (1993), or*

   B. *The Sheet Metal Air Conditioning Contractors National Association (SMACNA) Installation Standards for Residential Heating and Air Conditioning Systems, or*

   C. *The Air Conditioning Contractors Of America (ACCA) Manual J.*

   The design heat loss rate and design heat gain rate are two of the criteria that shall be used for equipment sizing and selection.

   NOTE to Section 150(h)1.: Heating Systems must meet the minimum heating capacity required by UBC Section 310.11. The furnace output capacity and other specifications are published in the Commission's directory of certified equipment or other directories approved by the Commission.

2. *Design Conditions.*

   For the purpose of sizing the space conditioning (HVAC) system, the indoor design temperatures shall be 70 degrees Fahrenheit for heating and 78 degrees for cooling. The outdoor design temperatures for heating shall be no lower than the Winter Median of Extremes column. The outdoor design temperatures for cooling shall be from the 0.5 percent Summer Design Dry Bulb and the 0.5 percent Wet Bulb columns for cooling, based on percent-of-year in ASHRAE publication SPCDX: Climate Data for Region X, Arizona, California, Hawaii, and Nevada, 1982, incorporated herein by reference.

Compliance/ Plan Check

Space Conditioning Sizing

The sizing of residential heating systems is regulated by the *Uniform Building Code (UBC)* and the standards. The UBC requires that the heating system be capable of maintaining a temperature of 70º F three feet above the floor throughout the conditioned space of the building.

Indoor Design Temperatures for Sizing Calculations

Heating	**Cooling**
70º F	78º F

If the actual city location for a project is not included in the ASHRAE listing, or if the data given for a particular city does not match the conditions at the actual site as well as that given for another nearby city, consult the local building department for guidance.

Design conditions for 641 California locations, from the ASHRAE publication *Climatic Data For Region X: Arizona, California, Hawaii, Nevada by ASHRAE* (Fifth Edition, May 1982, supplement November 1994), are contained in Appendix C.

The load calculations must be submitted with compliance documentation.


Construction

Space Conditioning Sizing

The mechanical contractor who installs the equipment, completes and signs the Installation Certificate (CF-6R) and is ultimately responsible for proper sizing and equipment selection.

The calculated heat gain and heat loss rates (load calculations) are just two of the criteria for sizing and selecting equipment. The load calculations may be prepared by: (1) the documentation author and submitted to the mechanical contractor, (2) a mechanical engineer, or (3) the mechanical contractor who is installing the equipment.

The load calculations do not need to be submitted with compliance documentation unless requested by the building department.


Energy Code

Setback Thermostats
Section 150(i))

(i) ***Setback Thermostats.*** *All heating and/or cooling systems other than wood stoves shall have an automatic thermostat with a clock mechanism or other setback mechanism approved by the Executive Director that shuts the system off during periods of non-use and that allows the building occupant to automatically set back the thermostat set points for at least 2 periods within 24 hours.*

EXCEPTION to Section 150(i): Gravity gas wall heaters, gravity floor heaters, gravity room heaters, non-central electric heaters, room air conditioners, and room air conditioner heat pumps need not comply with this requirement. Additionally, room air conditioner heat pumps need not comply with Section 112(b). The resulting increase in energy use due to elimination of the setback thermostat shall be factored into the compliance analysis in accordance with a method prescribed by the Executive Director.


Compliance/
Plan Check

Setback Thermostats

All heating and/or cooling systems must have an automatic setback thermostat with a clock mechanism that shuts the system off during periods of non-use and that allows the building occupant to automatically set back the thermostat set points for at least two periods within 24 hours.

An exception applies only when computer performance compliance with a “nonsetback” control modeled on the listed noncentral space-conditioning systems.

If more than one piece of heating equipment is installed in a residence or dwelling unit, the setback requirement may be met either by controlling all heating units by one setback thermostat or by controlling each unit with a separate setback thermostat. Separate heating equipment units may be provided with a separate on/off control capable of overriding the setback thermostat if desired.

Unless the elimination of the setback thermostat is factored into the compliance analysis for the following systems, the setback thermostat must be installed *(compliance with a prescriptive package always requires a setback thermostat):*

- Non-central electric heaters
- Room air conditioners
- Room air conditioner heat pumps
- Gravity gas wall heaters
- Gravity floor heaters
- Gravity room heaters
- Room air conditioners


Construction

Setback Thermostats

Automatic setback thermostats add both comfort and convenience to a home. Occupants can wake up to a warm house in the winter and come home

to a cool house in the summer without using unnecessary energy.

All heating and/or cooling systems must have an automatic setback thermostat with a clock mechanism that shuts the system off during periods of non-use and that allows the building occupant to automatically set back the thermostat set points for at least two periods within 24 hours.

The only exception is if the HVAC system on the CF-1R shows the thermostat type as "non-setback" for a building using computer performance compliance. This exception is not allowed for the alternative component packages because this approach cannot factor into the compliance the lack of setback capabilities. The exception also only applies to non-central systems as identified above.

Inspection

Setback Thermostats

Check the CF-1R for automatic setback thermostat requirements. A setback thermostat is a mandatory for central systems. The exception is twofold for non-central systems: (1) the building complied using a computer performance approach with a nonsetback thermostat; and (2) the system is one of the following non-central types:

- Non-central electric heaters
- Room air conditioners
- Room air conditioner heat pumps
- Gravity gas wall heaters
- Gravity floor heaters
- Gravity room heaters
- Room air conditioners

This exception is not allowed for alternative component packages because this approach cannot factor into the compliance the lack of setback capabilities.

Setback is typically achieved with a timeclock on the thermostat or with a digital readout.

Examples

Setback Thermostats

Am I exempt from the requirement for a setback thermostat if I have a gravity wall heater or any of the equipment types listed in the exception to Section 150(i)?

Exemption from the requirement depends on the compliance approach you are using. The latter part of the exception indicates that "the resulting increase in energy use due to the elimination of the setback thermostat shall be factored into the compliance analysis." The only compliance approach which can model this condition is the computer performance compliance approach. To be exempt from the setback thermostat requirement, the building/space must be modeled with "non-setback." Any time the alternative component packages are used for compliance, a setback thermostat is required, regardless of the type of heating/cooling system (except wood stoves).

Energy Code

Heat Pump Controls
(Section 112(b))

(b) ***Controls for Heat Pumps with Supplementary Electric Resistance Heaters****. Heat pumps with supplementary electric resistance heaters shall have controls:*

1. *That prevent supplementary heater operation when the heating load can be met by the heat pump alone; and*

2. *In which the cut-on temperature for compression heating is higher than the cut-on temperature for supplementary heating, and the cut-off temperature for compression heating is higher than the cut-off temperature for supplementary heating.*

EXCEPTION to Section 112(b): The controls may allow supplementary heater operation during:

I. *Defrost; and*

II. *Transient periods such as start-ups and following room thermostat setpoint advance, if the controls provide preferential rate control, intelligent recovery, staging, ramping, or another control mechanism designed to preclude the unnecessary operation of supplementary heating.*

Construction

Heat Pump Controls

Any heat pump with supplementary electric resistance heating must have controls that have two capabilities to limit the electric resistance heating. The first capability of the control is to set the cut-on and cut-off temperatures for compression and supplementary heating at different levels.

For example, if the heat pump begins heating when the inside temperature reaches 68ºF, the electric resistance heating is set to come on if the temperature gets below 65ºF; and the opposite off mode so that if the heat pump shuts off when the temperature reaches 72ºF, the back-up heating shuts off at 68ºF.

The second function of the control prevents the supplementary electric resistance heater from operating when the heat pump alone can meet the heating load, except during defrost.

There is a limited exception to this second function for "smart thermostats" that provide:

- intelligent recovery,
- staging,
- ramping, or
- another control mechanism that prevents the unnecessary operation of supplementary electric resistance heating when the heat pump alone can meet the heating load.

With such controls supplementary heater operation is permitted during defrost and transient periods such as start-ups, and following room thermostat setpoint advance.

NOTE:

Room air conditioner heat pumps are not required to comply with these requirements.

Energy Code

Water Heater Tank Insulation (Section 150(j)1)

A. Storage gas water heaters with an energy factor < 0.58 shall be externally wrapped with insulation having an installed thermal resistance of R-12 or greater.

B. Unfired hot water tanks, such as storage tanks and backup storage tanks for solar water heating systems, shall be externally wrapped with insulation having an installed thermal resistance of R-12 or greater or have internal insulation of at least R-16 and a label on the exterior of the tank showing the insulation R-value.

Compliance/ Plan Check

Water Heater Insulation

Insulation is not a factor in the compliance calculations, but is a mandatory requirement for some units. For storage water heaters with an energy factor of less than 0.58, an R-12 insulation wrap is required. Any unfired tanks (used as a back-up for solar water heating or as storage for a boiler) must either be insulated externally with R-12 or have a label indicating the tank is internally insulated with R-16.

Construction

Water Heater Insulation

Storage water heaters with an efficiency of less than 0.58 energy factor must be wrapped with an R-12 insulation blanket. Internal insulation cannot be substituted for this insulation. Large storage water heaters with a rated input greater than 75,000 Btuh that are not rated with an energy factor (EF) are not required to have an external R-12 insulation blanket.

Unfired tanks used as a back-up for solar water heating, or as storage for a boiler, must either be insulated externally with R-12 or have a label indicating that the tank is internally insulated with R-16. Alternatively, proof that the heat loss of the tank surface, based on an 80ºF water-air temperature difference, is less than 6.5 Btu/hr-ft^2.

Inspection

Water Heater Insulation

In most common situations a water heater blanket is not required. There are only two cases where an R-12 wrap is required:

- *Storage* water heater with an energy factor of less than 0.58.

- *Unfired* water heater without a label specifying R-16 internal insulation.

Energy Code

Pipe Insulation
(Section 150(j)2)

Piping, whether buried or unburied, for recirculating sections of domestic hot water systems, piping from the heating source to the storage tank for an indirect-fired domestic water heating system, cooling system piping below 55 degrees Fahrenheit, and the first five feet of hot and cold water pipes from the storage tank for non-recirculating systems shall be thermally insulated in accordance with Table No. 1-T.

EXCEPTIONS to Section 150(j)2.: The following piping does not have to be thermally insulated: (1) factory-installed piping within space conditioning equipment; and (2) piping that conveys fluids that have a design operating temperature range between 55 degrees and 105 degrees Fahrenheit.

NOTE to Section 150(j)2.: Where the Executive Director approves a water heater calculation method for a particular water heating recirculation system, piping insulation requirements shall be those specified in the approved calculation method.

Compliance/
Plan Check

Pipe Insulation

Pipe insulation is usually a mandatory requirement; however, in some cases credit for piping insulation is given. For more specific information about gaining credit for pipe insulation, see Chapter 5.

TABLE NO. 1-T
PIPE INSULATION REQUIREMENTS
MINIMUM R-VALUE

System	*Pipe Diameter*	
	Less than or equal to 2"	*Greater than 2"*
Domestic Hot Water	*R-4*	*R-6*
Hydronic Heating Supply Lines	*R-4*	*R-6*
Cooling Systems (pipes below 55°F)	*R-3*	*R-4*

Construction

Pipe Insulation

The following piping must be insulated in accordance with Table 1-T above:

- Storage tanks for a non-recirculating system must have pipe insulation on both hot and cold water pipes for a length of five feet. There is no exception for water heater piping in the conditioned space. Insulate the cold water pipe close to the storage tank since the cold water pipe draws heat from the tank and loses some of that heat convectively to the air.
- Recirculating sections of domestic hot water systems (the entire length of piping, whether buried or exposed).
- Indirect fired domestic hot water system piping from the heating source to the storage tank.
- Cooling system piping below 55ºF.

Other installation information:

- No insulation should be installed closer than six inches from the flue. If possible bend the pipe away from the flue, otherwise, it may be necessary to stop pipe insulation short of the storage tank (see *1994 Uniform Mechanical Code*, Section 304, Table 3C).
- All pipe insulation seams should be sealed.
- Installed piping should not be located in supply or return air plenums.
- Hot and cold water piping, when installed in parallel runs should be a minimum of six inches apart.
- If the pipe is interrupted by a wall, the wall insulation can, if it surrounds the pipe as shown in Figure 2-10, be used to meet the mandatory requirements in place of pipe insulation. The full five feet must be insulated.
- If a fire wall interrupts the first five feet of pipe, the insulation may be interrupted at the wall and continued on the other side.

Piping *exempt* from this insulation requirement includes:

- Factory installed piping within space conditioning equipment; and
- Piping that conveys fluids that have a design operating temperature range between 55ºF and 105ºF.

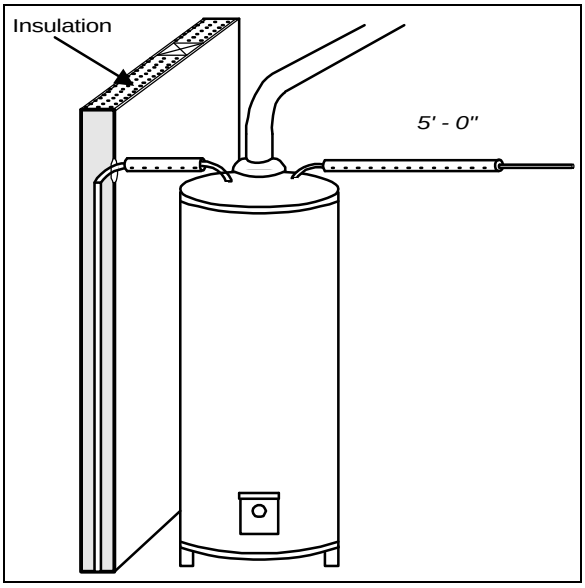


Figure 2-10: Meeting Pipe Insulation Requirements for Storage Tank Water Heaters

Inspection

Pipe Insulation

The following insulation is required (insulation values are for two inches or less pipes):

- R-4 on the first five feet of hot and cold water pipes for storage, non-recirculating system. There is no exception for water heater piping in the conditioned space.
- R-4 on the entire length of hot water recirculating piping on a recirculating system, regardless of the location of the piping.
- R-4 on piping from the heating source to the storage tank for boilers or solar water heating;
- R-3 on cooling system piping below 55ºF; and,
- Other insulation shown on the CF-1R is being used for a credit and must be installed as indicated on the plans.

I thought I was supposed to insulate the water heater pipes for either the first five feet or the length of piping before coming to a wall, whichever is greater. Did I misunderstand?

Yes. The requirement is that you must insulate the entire length of the first five feet, regardless of whether there is a wall (standards, Section 150(j)2). You have two options: (1) interrupt insulation for a fire wall and continue it on the other side of the wall, or (2) run the pipe through an insulated wall, making sure that the wall insulation completely surrounds the pipe.

When insulating the water heater piping, do I need to put insulation on the first five feet of cold water pipe?

Yes. Section 150(j)2 requires insulation on the cold water pipe also. When heated, the water expands and pushes hot water out the cold water line. This can start thermosyphoning, which continues to remove heat from the stored water. The insulation helps reduce this effect.

If the energy calculations show R-4 pipe insulation, is this a credit? What are the installation requirements for obtaining credit?

If R-4 pipe insulation is indicated on any form other than the MF-1R it is being used to obtain credit. (The MF-1R form indicates only mandatory insulation requirements—the first ***five*** feet of piping for a non-recirculating system or the entire length of recirculating sections of hot water piping for a circulating system.) If R-4 is indicated on the Computer Summary (C-2R) or the Certificate of Compliance (CF-1R) it is being calculated as a credit.

The installation requirements for receiving the R-4 piping insulation *credit* are:

- A non-recirculating water-heating system
- R-4 (or greater) insulation
- Insulation applied to all 3/4 inch or larger hot water mains
- Neither attic, wall nor underfloor insulation can be used as a substitute for this insulation.
- These requirements are in addition to mandatory insulation requirements of Section 150(j).

Can I get pipe insulation credit for a recirculating water-heating system?

No. Recirculating water-heating systems have a mandatory insulation requirement for the recirculating sections of hot water pipes. Pipes less than 2 inches must be insulated to R-4 and pipes greater than 2 inches need R-6 insulation.

When I'm insulating the pipes for a recirculating water-heating system, I insulate the entire length of hot water pipes. Do I need to insulate the runouts?

No. Since the water in runouts does not recirculate, they do not need to be insulated.

Energy Code

Solar Water Heating
(Section 150(j)3)

Solar water heating systems and/or collectors shall be certified by the Solar Rating and Certification Corporation.

Compliance/
Plan Check

Solar Water Heating

Solar water-heating systems and/or collectors must be certified by the Solar Rating and Certification Corporation (SRCC) as explained in Chapter 5.

Inspection

Solar Water Heating

- Certification of solar system and/or collectors by the Solar Rating and Certification Corporation (SRCC)
- Piping insulation from the indirect fired hot water system to the heat source
- Tank insulation on an indirect fired water heater without a label specifying R-16 internal insulation.

Introduction

Ducts, Plenums and Fans

The discussion of ducts contained in this chapter focuses on minimum mandatory requirements for duct construction, including excerpts from the *Uniform Mechanical Code* and construction details from the Air Diffusion Council. Chapter 4 and Appendicies J and K contain additional details on constructing tight ducts to eliminate potentially significant energy losses created by leaky ducts. Criteria for obtaining compliance credit for tight duct systems is also outlined in Chapter 4.

Energy Code

Ducts, Plenums and Fans (Section 150(m))

1. *UMC Compliance. All air distribution system ducts and plenums, including but not limited to building cavities, mechanical closets, air handler boxes and support platforms used as ducts or plenums, shall be installed, sealed and insulated to meet the requirement of the ICBO 1997 UMC Sections 601, 603, 604 and Standard 6-3, incorporated herein by reference. Portions conveying conditioned air shall either be insulated to a minimum installed level of R-4.2 (or any higher level required by UMC Section 604) or be enclosed entirely in conditioned space. Connections of metal ducts and the inner core of flexible ducts shall be mechanically fastened. Openings shall be sealed with mastic, tape, aerosol sealant or other duct closure system that meets the applicable requirements of UL 181, UL 181A or UL 181B. If mastic or tape is used to seal openings greater than 1/4 inch, the combination of mastic and either mesh or tape shall be used.*

***NOTE:** If the requirements of UL181, UL181A, or UL181B do **not** apply to the particular tape, aerosol sealant, or duct closure system being used, then those requirements are met for that particular application.*

2. *Factory-Fabricated Duct Systems.*

   A. *All factory-fabricated duct systems shall comply with UL 181 for ducts and closure systems, including collars, connections and splices.*

   B. *All pressure-sensitive tapes, heat-activated tapes, and mastics used in the manufacture of rigid fiberglass ducts shall comply with UL 181.*

   C. *All pressure-sensitive tapes, mastics used with flexible ducts shall comply with UL 181 or UL 181B.*

3. *Field-Fabricated Duct Systems.*

   A. *Factory-made rigid fiberglass and flexible ducts for field-fabricated duct systems shall comply with UL 181. All pressure-sensitive tapes, mastics, aerosol sealants or other closure systems used for installing field-fabricated duct systems shall meet the applicable requirements of UL 181, UL 181A or UL 181B. Note: If these requirements do not apply then they are met.*

   B. *Mastic Sealants and Mesh.*

      i. *Sealants shall comply with UL 181, UL 181A, or UL 181B, and be non-toxic and water resistant.*

      ii. *Sealants for interior applications shall pass ASTM tests C 731(extrudability after aging) and D 2202 (slump test on vertical surfaces), incorporated herein by reference.*

      iii. *Sealants for exterior applications shall pass ASTM tests C 731, C 732 (artificial weathering test) and D 2202, incorporated herein by reference.*

      iv. *Sealants and meshes shall be rated for exterior use.*

   C. *Pressure-Sensitive Tape. Pressure-sensitive tapes shall comply with UL 181, UL 181A, or UL 181B.*

   D. *Drawbands Used with Flexible Duct.*

      i. *Drawbands shall be either stainless-steel worm-drive hose clamps or uv-resistant nylon duct ties.*

ii. Drawbands shall have a minimum tensile strength rating of 150 pounds.

iii. Drawbands shall be tightened as recommended by the manufacturer with an adjustable tensioning tool.

E. Aerosol-Sealant Closures.

*i. Aerosol sealants shall meet the **applicable** requirements of UL 181, 181A or 181B and be applied according to manufacturer specifications. If the requirements of UL181, UL181A, or UL181B do not apply then these requirements are met.*

ii. Tapes or mastics used in combination with aerosol sealing shall meet the requirements of this section.

4. All duct insulation product R-values shall be based on insulation only (excluding air films, vapor barriers, or other duct components) and tested C-values at 75°F mean temperature at the installed thickness, in accordance with ASTM C518-85 or ASTM C177-85, incorporated herein by reference, and certified pursuant to Section 118.

5. The installed thickness of duct insulation used to determine its R-value shall be determined as follows:

A. For duct board, duct liner and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used.

B. For duct wrap, installed thickness shall be assumed to be 75 percent (25 percent compression) of nominal thickness.

C. For factory-made flexible air ducts, the installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by 2.

6. Insulated flexible duct products installed to meet this requirement must include labels, in maximum intervals of 3 feet, showing the thermal performance R-value for the duct insulation itself (excluding air films, vapor barriers, or other duct components), based on the tests in Section 150(m)2. and the installed thickness determined by Section 150(m)3.C.

7. All fan systems, regardless of volumetric capacity, that exhaust air from the building to the outside shall be provided with backdraft or automatic dampers to prevent air leakage.

8. All gravity ventilating systems that serve conditioned space shall be provided with either automatic or readily accessible, manually operated dampers in all openings to the outside except combustion inlet and outlet air openings and elevator shaft vents.

EXCEPTION to Section 150(m)1.: The requirements do not apply to ducts and fans integral to a wood heater or fireplace.

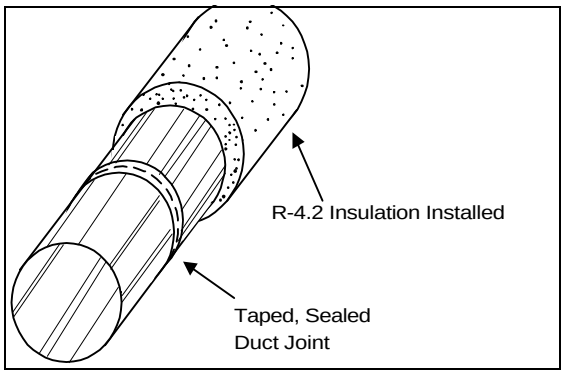


Figure 2-11: Duct Requirements


Compliance/
Plan Check

Ducts, Plenums and Fans

Ducts conveying conditioned air must either be insulated to a minimum installed level of R-4.2 (or any higher level required by the UMC Section 604) or be enclosed entirely in conditioned space (see Figure 2-11).

All duct insulation product R-values shall be based on insulation only (excluding air films, vapor barriers or other duct components) and tested c-values as specified above in Section 150(m)4. and certified pursuant to Section 118.

The installed thickness of duct insulation used to determine its R-value shall be determined in accordance with Section 150(m)5.

INSULATION AND INSTALLATION

Air handling ducts and plenums, and any building spaces used as a duct or plenum, must meet UMC Section 601 (material) and 603 (installation) requirements, and Standard 6-3 (See figures 2-12 through 2-18 for duct construction requirements from the UMC.)

Ducts conveying conditioned air must either be enclosed entirely in conditioned space or insulated to a minimum installed level of R-4.2 (unless a higher level is required by the UMC). In two situations Section 604 of the UMC requires R-6.3 duct insulation instead of R-4.2:

1. When cooling system ducts are installed on the roof or exterior of the building.
2. When heating system ducts are installed on the roof (exterior) of the building in an area with greater than 8,000 heating degree days (see Appendix C heating degree days (HDD)).

NOTE:

- The insulation levels of the UMC are mandatory *minimum* levels. If compliance calculations show a higher R-value is being used for credit, the higher value is required.
- The duct location must match the location showed on the Certificate of Compliance (CF-1R).

Additional duct construction requirements include:

1. Mechanical fastening of connections of metal ducts and the inner core of flexible ducts is required.
2. Openings must be sealed with mastic, tape, aerosol sealant or other duct closure systems that meet the applicable requirements of UL 181.
3. Openings larger than 1/4 inch must be sealed with a combination of mastic and either mesh or tape.

Ducts and fans integral to a wood heater or fireplace are exempt from these insulation and installation requirements.

FACTORY-FABRICATED DUCT SYSTEMS

1. Duct systems comply with UL 181 for ducts and closure systems, including collars, connections and splices.
2. All pressure-sensitive tapes, heat-activated tapes (for fiberglass ducts only), and mastics used to make rigid fiberglass or flexible ducts must comply with UL 181 or UL 181B.

FIELD-FABRICATED DUCT SYSTEMS

1. Factory-made fiberglass and flexible ducts must comply with UL 181.
2. All pressure-sensitive tapes, mastics, aerosol sealants or other closure systems must meet applicable UL 181, UL 181A or UL 181B requirements.

Pressure-Sensitive Tape

- Pressure-sensitive tapes shall comply with applicable UL 181, UL 181A or UL 181B requirements.

Mesh and Mastic Sealants

Mesh and mastic sealants must:

- Be UL 181, UL 181A or UL 181B complying, non-toxic and water resistant.
- Pass appropriate ASTM tests specified in Section 150(m)3.B above for either interior or exterior use.

Aerosol-Sealant Closures

- Aerosol sealants must meet applicable UL 181, UL 181A or UL 181B requirements and be applied as specified by the manufacturer.
- If tapes or mastics are used in combination with aerosol sealing, they must meet the requirements specified above.

Drawbands Used with Flexible Duct

Drawbands shall:

- Be either stainless-steel worm-drive hose clamps or uv-resistant nylon duct ties.
- Have a minimum tensile strength rating of 150 pounds.

- Be tightened as recommended by the manufacturer with an adjustable tensioning tool.

PRODUCT MARKINGS

Insulated flexible duct products installed to meet this requirement must include labels, in maximum intervals of three feet, showing the R-value for the duct insulation (excluding air films, vapor barriers or other duct components), based on the tests and thickness specified in Section 150(m) above.

FAN, EXHAUST AND VENTILATION

Fan systems that exhaust air from the building to the outside must be provided with back draft or automatic dampers.

Gravity ventilating systems must have an automatic or readily accessible, manually operated damper in all openings to the outside, except combustion inlet and outlet air openings and elevator shaft vents. This includes clothes dryer exhaust when installed in conditioned space.

Inspection

Ducts, Plenums and Fans

INSTALLATION AND INSULATION

Any building spaces used as a duct or plenum, must meet UMC Section 601 (material) and 603 (installation) requirements, and Standard 6-3.

Ducts in unconditioned spaces must be insulated to a minimum installed level of R-4.2 unless a higher level is required by the UMC or by the compliance calculations. All duct insulation and all insulated flexible ducts must have labels specifying tested R-values at installed thicknesses. These R-values must correspond to those specified on the CF-1R form.

Additionally,

- Mechanical fastening of connections of metal ducts and the inner core of flexible ducts is required.
- Openings must be sealed with mastic, tape, aerosol sealant or other duct closure systems that meet the applicable requirements of UL 181.
- Opening larger than 1/4 inch sealed with mastic or tape must be sealed with a combination of mastic and either mesh or tape.

Ducts and fans integral to a wood heater or fireplace are exempt from these insulation and installation requirements.

DUCT LOCATION

Duct location should be as specified on the CF-1R. Compliance can be dependent on the duct location assumed in the calculations. For example, if ducts are specified in conditioned space but installed in the attic, the plan checker will need to approve the change.

FACTORY-FABRICATED DUCT SYSTEMS

1. Duct systems comply with UL 181.
2. All pressure-sensitive tapes, heat-activated tapes, and mastics must comply with UL 181.

FIELD-FABRICATED DUCT SYSTEMS

1. Ducts must comply with UL 181.
2. All pressure-sensitive tapes, mastics, aerosol sealants or other closure systems must meet applicable UL requirements.

   Pressure-sensitive tapes shall comply with applicable UL 181 requirements.

   Mastic and mesh sealants must:

   - Be UL complying, non-toxic and water resistant.
   - Pass appropriate ASTM tests for their specific use.

   Aerosol-sealant closures:

   - Must meet applicable UL 181 requirements and be applied as specified by the manufacturer.
   - When used in combination with tapes or mastics, the tape or mastic must meet the requirements specified above.

   Drawbands used with flexible duct shall:

   - Be either stainless-steel worm-drive hose clamps or uv-resistant nylon duct ties.
   - Have a minimum tensile strength rating of 150 pounds.

- Be tightened as recommended by the manufacturer with an adjustable tensioning tool.

FAN, EXHAUST AND VENTILATION

Fans that exhaust air from the building to the outside must be provided with back draft or automatic dampers.

Gravity ventilating systems must have either an automatic or readily accessible, manually operated damper in all openings to the outside. This includes clothes dryer exhaust when installed in conditioned space. Exception: combustion inlet and outlet air openings, and elevator shaft vents.

Credit for quality constructed ducts that go beyond minimum mandatory requirements is available as detailed in Chapter 4Sections 4.xx through 4.yy.

Chapter 9 also contains a detailed listing for inspecting quality constructed ducts and Section 6.310 of Standard 6-3 of the UMC has an enforcement checklist for flexible duct installations

Duct Installation Standards
Uniform Mechanical Code (Standard 6-3)

These standards from the UMC are based on the descriptions given in *Flexible Duct Performance and Installation Standards.* published by the Air Diffusion Council, 104 South Michigan avenue, Suite 1500, Chicago, Illinois 60603, telephone (312) 201-0101.

Note: These are minimum standards. Compliance with these standards is not sufficient to qualify for compliance credits for quality-constructed duct systems. These compliance credits are not allowed for duct systems that use fabricated, rubber adhesive duct tape unless it is installed in combination with mastic and drawbands. Also, these compliance credits are not allowed if building space s are used as a duct or plenum. These compliance credits are only allowed for duct systems that are carefully designed and installed.

Ducts shall be installed fully extended as shown in Figure 2-12. If compressed or with excess lengths, as shown in Figure 2-13, friction losses are increased.

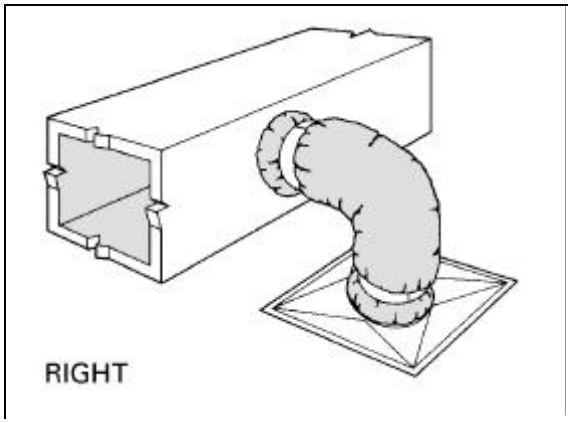


Figure 2-12: Duct Installation (Right)

Avoid bending ducts across sharp corners or incidental contact with metal fixtures, pipes or conduits. Also avoid installing the duct near hot equipment such as furnaces, boilers, or steam pipes, that is above the recommended flexible duct use temperature.

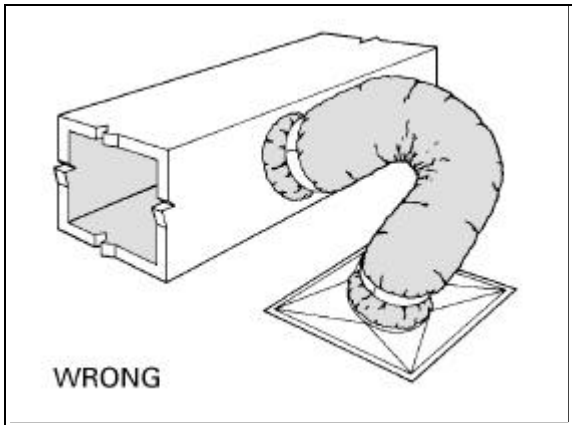


Figure 2-13: Duct Installation (Wrong)

Connecting, Joining and Splicing Flexible Duct

All connections, joints and splices shall be made in accordance with the manufacturer's installation instructions.

For flexible ducts with plain ends, standardized installation instructions are shown in Figures 2-14A-C for nonmetallic ducts and Figures 2-15A-C for metallic ducts. Because of the variety of ducts and duct assemblies with special end treatments, no standardized installation instructions are shown. Instead, consult the manufacturer's installation instructions.

Sheet metal collars to which the flexible ducts with plain ends are attached shall be a minimum of 2 inches in length.

Sheet metal sleeves used for joining two sections of flexible ducts with plain ends shall be a minimum of 4 inches in length.

Sheet metal collars and sleeves should be beaded for pressures exceeding 2 inches w.g. (500 Pa) and for diameters 12 inches and larger when used with metallic ducts.

Nonmetalic Air Ducts and Air Connectors

Cut completely around and through duct with knife or scissors. Cut wire with wire cutters (Figure 2-14A).

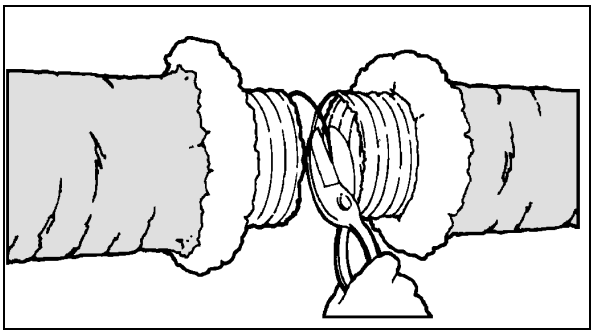


Figure 2-14A: Connections for Nonmetallic Air Ducts and Air Connectors

Pull jacket and insulation back from core. Slide at least 1 inch of core over collar, pipe or fitting. Tape core with at least two wraps of duct tape. Secure with a clamp (Figure 2-14B**)**.

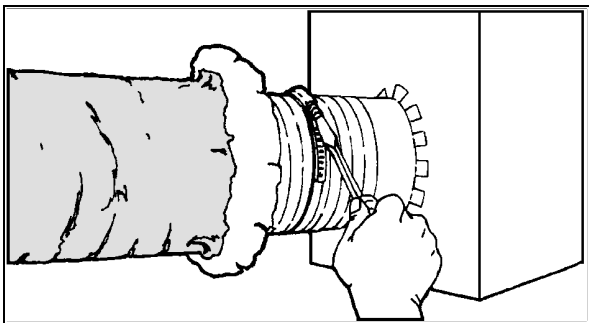


Figure 2-14B: Connections for Nonmetallic Air Ducts and Air Connectors

Pull jacket and insulation back over core. Tape jacket with at least two wraps of duct tape. A clamp may be used in place or in combination with the duct tape (Figure 2-14C).

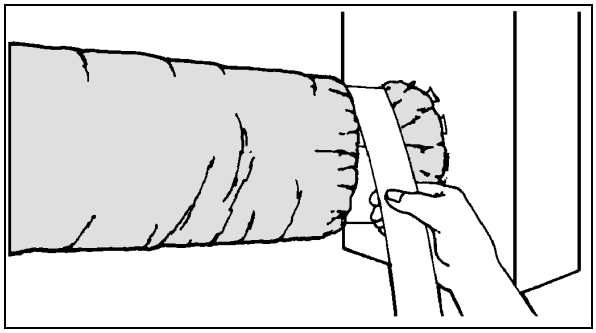


Figure 2-14C: Connections for Nonmetallic Air Ducts and Air Connectors

Peel back jacket and insulation from core. Butt two cores together on a standard 4-inch metal sleeve (Figure 2-15A).

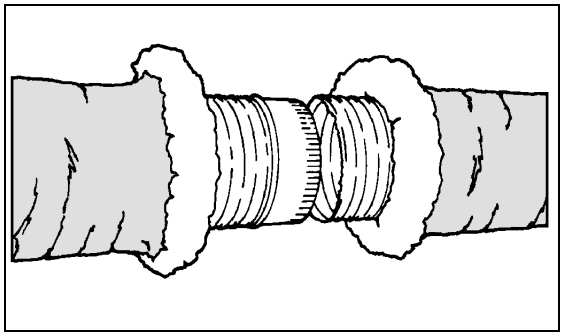


Figure 2-15A: Splices for Nonmetallic Air Ducts and Air Connectors

Tape core with at least two wraps of duct tape. Secure with two clamps (Figure 2-15B).

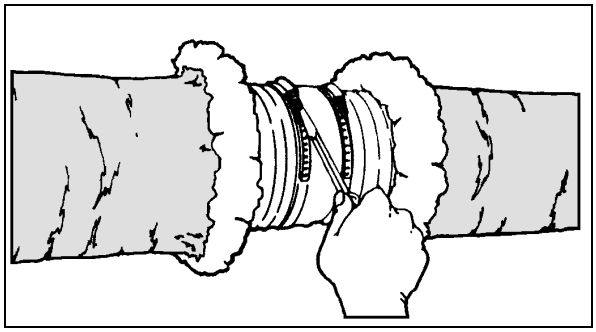


Figure 2-15B: Splices for Nonmetallic Air Ducts and Air Connectors

Pull jacket and insulation back over cores. Tape jacket. Tape jacket with at least two wraps of duct tape (Figure 2-15C).

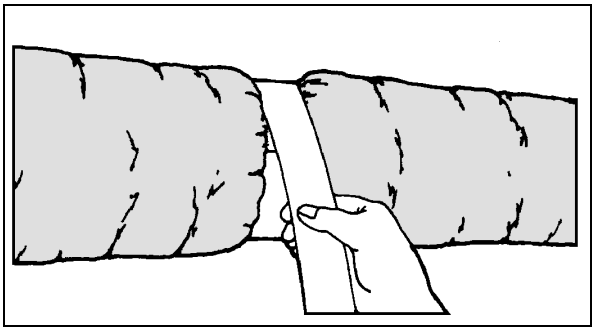


Figure 2-15C: Splices for Nonmetallic Air Ducts and Air Connectors

NOTES (for Figures 2-14 and 2-15):

1. Use beaded fittings for pressures exceeding 2 inches w.g. (500 Pa) and for diameters 12 inches and larger.
2. Use tapes listed and labeled to Standard UL 181B and marked 181B-FX.
3. Use clamps as specified on manufacturer's UL 181 installation instructions.

After cutting duct to desired length, fold back jacket and insulation exposing core. Trim core ends squarely using metal shears (Figure 2-16A). Determine optional sealing method (Figure 2-16B or 2-16E) before proceeding.

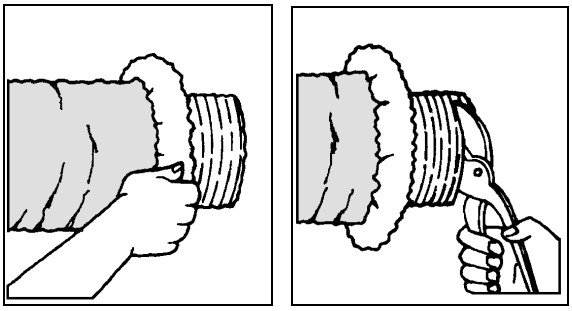


Figure 2-16A: Connections and Splices for Metallic Air Ducts and Air Connectors

When mastics are required, and for pressures 4 inches w.g. (1000 Pa) and over, seal joint with mastic applied uniformly to the outside surface of collar/sleeve (Figure 2-16B). Disregard this step when not using mastics and proceed to Figure 2-16C.

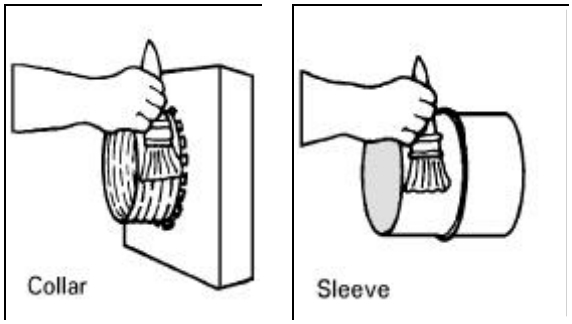


Figure 2-16B: Connections and Splices for Metallic Air Ducts and Air Connectors

Slide at least 1 inch of core over metal collar for attaching duct to take off or over ends of a 4-inch metal sleeve for splicing two lengths of duct (Figure 2-16C).

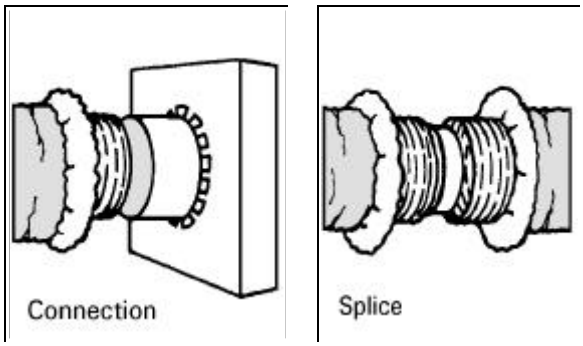


Figure 2-16C Connections and Splices for Metallic Air Ducts and Air Connectors

Secure to collar/sleeve using #8 sheet metal screws spaced equally around circumference. Use three screws for diameters under 12 inches and five screws for diameters 12 inches and over (Figure 2-16D).

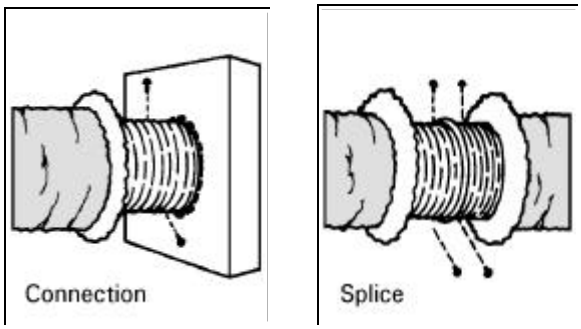


Figure 2-16D: Connections and Splices for Metallic Air Ducts and Air Connectors

For pressures under 4 inches w.g. (1000 Pa) and over, seal joint with mastic applied uniformly to the outside surface of collar/sleeve (Figure 2-16E). Disregard this step when not using mastics and proceed to Figure 2-16C.

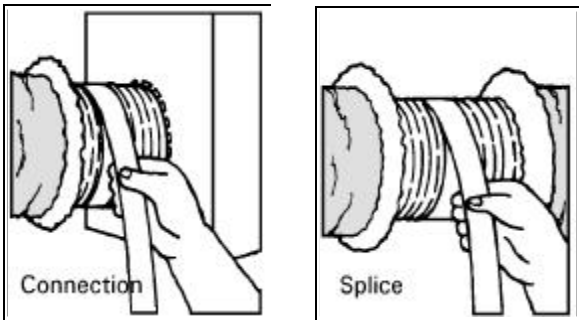


Figure 2-16E: Connections and Splices for Metallic Air Ducts and Air Connectors

Pull jacket and insulation back over core. Tape jacket with two wraps of duct tape. A clamp may be used in place or in combination with the duct tape (Figure 2-16F).

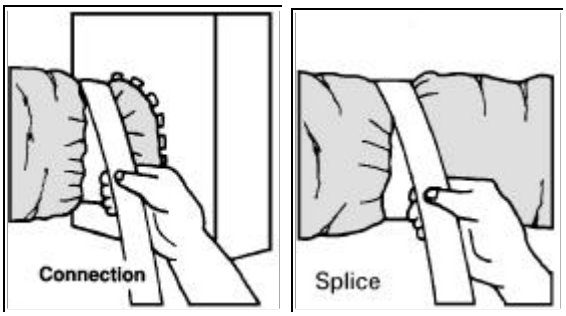


Figure 2-16F: Connections and Splices for Metallic Air Ducts and Air Connectors

NOTES (for Figures 2-16A through F):

1. For uninsulated air ducts and air connectors, disregard references to insulation and jacket.
2. Use mastics listed and labeled to Standard UL 181B and marked 181B-M on container.
3. Use tapes listed and labeled to Standard UL 181B and marked 181B-FX.
4. Use clamps as specified on manufacturer's UL 181 installation instructions.

Supporting Flexible Duct

Flexible duct shall be supported at manufacturers recommended intervals, but no greater than a distance of five feet (see Figure 2-17). Maximum permissible sag is 1/2 inch per foot of space between supports.

A connection to rigid duct or equipment shall be considered a support joint. Long horizontal duct runs with sharp bends shall have additional supports before and after the bend approximately one duct diameter from the center line of the bend.

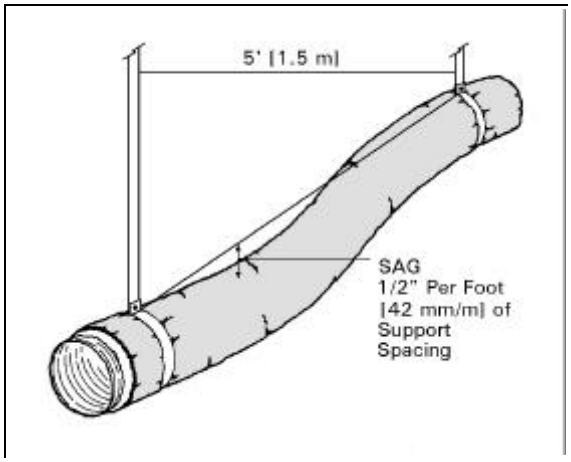


Figure 2-17: Flexible Duct Support

Hanger or saddle material in contact with the flexible duct shall be of sufficient width to prevent any restriction of the internal diameter of the duct when the weight of the supported section rests on the hanger or saddle material. In no case will the material in contact with the flexible duct be less than 1-1/2 inches wide (see Figure 2-18).

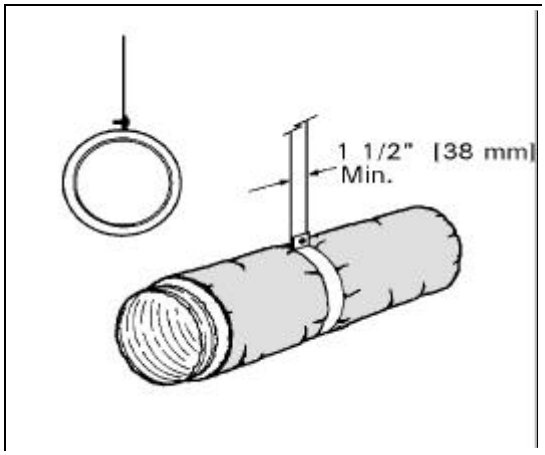


Figure 2-18: Hanger or Saddle Material

Suggested Installation Restrictions and Use Limitations

The Air Diffusion Council's publication for flexible ducts notes that there are specific restrictions and limitations related to the use of flexible duct. Some are due to National Fire Protection Association Standard, model codes and various state/local codes. Others are due to end use performance where the product was not designed for that specific use. Some (not all inclusive) are:

- Cannot be used for vertical risers serving more than two stories in height.
- Cannot be used in systems with entering air temperature higher than 250°F.
- Must be installed in accordance with conditions of listing.
- When installed in a fire-rated floor/roof ceiling assembly, ducts shall conform with the design of the tested fire-resistive assembly.
- Should be interrupted at the immediate area of operation of electric, fossil fuel or solar energy collection heat sources to meet listed equipment clearances specified.
- Air connectors (does not apply to air ducts) shall not be installed in lengths greater than 04 feet for any given run; shall not pass through any wall, partition or enclosure of a vertical shaft with a 1 hour or more fire resistive rating; shall not pass through floors.
- Should not penetrate walls where fire dampers are required.
- Should not be used outdoors unless specifically designed to withstand exposure to direct sunlight and the weathering elements.
- Should not be used to vent appliances for cooking, heating and clothes drying unless approved and recommended by the appliance manufacturer.
- Should not be installed in concrete, buried below grade or in contact with the ground.

Suggested Duct Sizing Guidelines

The combined friction and dynamic pressure losses must be taken into consideration to properly size any duct. Pressure losses caused by the roughness of the duct wall resisting air movement are known as friction losses. Pressure losses when air flow changes direction, as caused by bends or when air flows across other system components, are known as dynamic losses.

To prevent undersizing or oversizing of flexible ducts and achieve the designed air delivery performance:

- Have an understanding of and properly use the air friction chart.
- Use a proven method of duct sizing, one that has taken into consideration both friction and dynamic losses.
- Use friction loss data characteristic of flexible duct. Do not use data for round sheet metal duct.
- Since all flexible duct is not alike, use the published data from the manufacturer of the specific flexible duct being used.

Suggestions for Avoiding Duct Leakage

To assure low leakage rate in flexible duct, the following practices are recommended:

- Reference industry manuals (SMACNA, NAIMA) for making round tap-ins into and sealing fitting joints to rigid ducts, plenums, etc.
- Make flexible duct connections/splices in accordance with manufacturer's recommended installation instructions.
- Seal flexible duct connections with sealing materials listed and labeled to UL 181B. Mechanically secure connections with approved clamping material.
- Repair any rip, tear or hole in the air barrier using materials listed and labeled to Standard UL 181B and methods recommended by the manufacturer.

Energy Code

Pool and Spa Equipment (Section 114)

Mandatory Requirements for Pool and Spa Heating Systems and Equipment.

(a) ***Certification by Manufacturers****. Any pool or spa heating system or equipment may be installed only if the manufacturer has certified that the system or equipment has all of the following:*

1. ***Efficiency****. A thermal efficiency for gas-fired systems of at least 78%, when tested according to ANSI Standard Z21.56-1994; and*
2. ***On-Off Switch****. A readily accessible on-off switch, mounted on the outside of the heater, that allows shutting off the heater without adjusting the thermostat setting; and*
3. ***Instructions****. A permanent, easily readable, and weatherproof plate or*

card that gives instruction for the energy efficient operation of the pool or spa and for the proper care of pool or spa water when a cover is used; and

4. ***Electric Resistance Heating**. No electric resistance heating; and*

EXCEPTION No. 1 to Section 114(a)4.: Listed package units with fully insulated enclosures, and with tight-fitting covers that are insulated to at least R-6.

EXCEPTION No. 2 to Section 114(a)4.: Pools or spas deriving at least 60% of the annual heating energy from site solar energy or recovered energy.

5. ***Pilot Light**. No pilot light.*

(b) ***Installation**. Any pool or spa heating system or equipment shall be installed with all of the following:*

1. ***Piping**. At least 36" of pipe between the filter and the heater, to allow for the future addition of solar heating equipment; and*

2. ***Covers**. A cover for outdoor pools or outdoor spas; and*

EXCEPTION to Section 114(b)2.: Pools or spas deriving at least 60% of the annual heating energy from site solar energy or recovered energy.

3. ***Directional Inlets and Time Switches for Pools**. If the system or equipment is for a pool:*

A. The pool shall have directional inlets that adequately mix the pool water; and

B. The circulation pump shall have a time switch that allows the pump to be set to run in the off-peak electric demand period, and for the minimum time necessary to maintain the water in the condition required by applicable public health standards.

EXCEPTION to Section 114(b)3.B.: Where applicable public health standards require on-peak operation.

Compliance/ Plan Check

Pool and Spa Equipment

Before any pool or spa heating system or equipment may be installed, the manufacturer must certify to the Commission that the system or equipment complies with Section 114. The requirements include minimum heating efficiency, an on-off switch, permanent operating instructions, no pilot light and no electric resistance heating, with two exceptions. Electric resistance heating may be installed for:

1. Listed package units with fully insulated enclosures (e.g., hot tubs), and with tight-fitting covers, insulated to at least R-6.

2. Pools or spas getting 60 percent or more of their annual heating from site solar energy or recovered energy.

Construction

Pool and Spa Equipment

Any pool or spa must be installed with all of the following:

- At least 36 inches of pipe between the filter and heater to allow for the future addition of solar heating equipment;

- A cover for outdoor pools or outdoor spas except for pools or spas deriving at least 60 percent of the annual heating energy from site solar energy or recovered energy;

- If the heating system or equipment is for a pool:

  a. The pool must have directional inlets to adequately mix the pool water; and

  b. The circulation pump must be capable of being set to run for the minimum number of hours to maintain the water in an acceptable condition and to run at off-peak electric demand periods.

Inspection

Pool and Spa Equipment

EQUIPMENT

Gas:

1. Thermal efficiency 78 percent,
2. Accessible shut-off switch (independent of temperature),
3. Permanent and readable instructions for efficient operation and maintenance, and
4. No pilot light.

Electric:

NOT ALLOWED except when:

1. At least 60 percent solar heating or site recovered energy provided, and
2. Package unit has fully insulated enclosure with tight-fitting, R-6 cover (e.g., hot tub).

INSTALLATION

1. At least 36-inch pipe length between filter/ heater (for future solar),
2. Cover (except if solar heating),
3. Ability to mix pool water, and
4. Time switch for pool pump (allows control of length of time and time of day)

Energy Code

Pilot Lights Prohibited (Section 115)

Natural Gas Central Furnaces, Cooking Equipment, and Pool and Spa Heaters: Pilot Lights Prohibited.

Any natural gas system or equipment listed below may be installed only if it does not have a continuously burning pilot light:

(a) Fan type central furnaces.

(b) Household cooking appliances.

EXCEPTION to Section 115(b): Household cooking appliances without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/hr.

(c) Pool heaters.

(d) Spa heaters.

Construction

Pilot Lights Prohibited

Any of the following natural gas systems or equipment may be installed only if it does *not* have a continuously burning pilot light:

- Fan type central furnaces
- Household cooking appliances, except cooking appliances without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/hr
- Pool heaters
- Spa heaters
- Fireplace*
- Decorative gas appliance*
- Gas log*

*Section 150(e) specifies that a fireplace, decorative gas appliance, gas log cannot have a continuously burning pilot light.

Inspection

Pilot Lights Prohibited

The following natural gas appliances cannot have a standing or continuously burning pilot light:

- Fan type central furnaces
- Household cooking appliances, except cooking appliances without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/hr
- Pool heaters
- Spa heaters
- Fireplace
- Decorative gas appliance
- Gas log

Examples

Pilot Lights Prohibited

Under what circumstances is a constantly (or continuously) burning pilot light prohibited on certain appliances?

For compliance with the standards, Section 115 prohibits continuously burning pilot lights for some natural gas burning equipment (this does not include liquefied petroleum gas burning appliances). The equipment types are:

- Household cooking appliances with an electrical supply voltage connection in which each pilot consumes 150 Btu/hr or more
- Pool heaters
- Spa heaters
- Fan type central furnaces

Section 150(e) prohibits continuously burning pilot lights for:

- Fireplaces
- Decorative gas appliances
- Gas logs

For compliance with federal and state appliance regulations (which apply to any appliance sold or offered for sale in California), a constant burning pilot light is prohibited on:

- Gas kitchen ranges and ovens with an electric supply cord
- Pool heaters, except those that burn liquefied petroleum gas

2.5 LIGHTING

Energy Code

Kitchen Lighting (Section 150(k)1, 3)

1. *Luminaires for general lighting in kitchens shall have lamps with an efficacy of not less than 40 lumens per watt. General lighting must provide a sufficient light level for basic kitchen tasks and provide a uniform pattern of illumination. A luminaire(s) that is(are) the only lighting in a kitchen will be considered general lighting. General lighting shall be controlled by a switch on a readily accessible lighting control panel at an entrance to the kitchen.*

   Additional luminaires to be used only for specific decorative effects need not meet this requirement.

3. *Luminaires installed to meet the 40 lumens per watt requirements of Section 150(k) 1. or 2. shall not contain medium base incandescent lamp sockets, and shall be on separate switches from any incandescent lighting.*

Construction

Kitchen Lighting

Installing energy-efficient lamps and fixtures can reduce lighting energy costs without sacrificing the quality or quantity of light available. As indicated in Table 2-2, a 40-watt standard fluorescent lamp is over four times as efficient as a 100-watt standard incandescent lamp.

The general lighting in kitchens must:

- Have an efficacy of *at least 40 lumens/watt* (see Table 2-2).
- Provide a uniform pattern of lighting, such as a fixture in the center of the kitchen or around the perimeter (not a fixture in the corner).
- Provide a light level sufficient for performing basic kitchen tasks such as preparing meals and washing dishes.
- Be controlled on a readily accessible switch at an entrance to the kitchen (not in a cupboard or beside the kitchen sink).
- Be switched independent of incandescent lighting.
- Shall not contain medium-base incandescent lamp sockets. This prevents the occupant from replacing the efficient light source with an incandescent bulb.

If there is only one light in the kitchen, it is general lighting.

Additional luminaires for decorative effect do not need to meet these requirements

Incandescent lighting fixtures recessed into insulated ceilings must be approved for zero-

clearance insulation cover (IC-rated) in compliance with Section 150(k)4 (see below).


Inspection

Kitchen Lighting

The lighting in the kitchen, either general or the only lighting, must:

- Be fluorescent or another product that has at least 40 lumens/watt (see Table 2-2).
- Provide a uniform pattern of lighting, such as a fixture in the center of the kitchen or around the perimeter (not a fixture in the corner).
- Provide a light level sufficient for performing basic kitchen tasks such as preparing meals and washing dishes.
- Be controlled on a readily accessible switch at an entrance to the kitchen (not in a cupboard or beside the kitchen sink).
- Be switched separately from incandescent lighting and on a control panel at an entrance to the kitchen.
- Not contain medium-base incandescent lamp sockets. This prevents the occupant from replacing the efficient light source with an incandescent bulb.

Table 2-2. Typical Efficacy of Luminaries

Light Source	Type	Rated Lamp Watts	Typical Efficacy Lumens/Watt[1]
Incandescent	Standard	40 - 100	14 - 18
Incandescent	Halogen	40 - 250	20[2]
Incandescent	Halogen IR	See footnote [3]	Up to 30
Fluorescent (Lamp/Ballast Systems)[4]	Full-Size, 4' Long	32 - 40	69 - 91
	U-Shaped T-8 Bipin	16 - 31	78 - 90
	Compact Fluorescent	5 - 9	26 - 38
	Compact Fluorescent	13 +	42 - 58
Metal Halide	Metal Halide	32 - 175	50 - 90
High Pressure Sodium	White High Pressure Sodium	35 - 100	36 - 55

[1] Includes power consumed by ballasts where applicable.

[2] Halogen capsule incandescent lamps may be the most efficient light source for highlighting applications. Most halogen lamps are designed to produce a beam of directed light. Manufacturer's data typically list the "candlepower" intensity of that beam, rather than lumens (lumens measure total light output in all directions).

[3] A new technology using infrared reflecting films on the halogen capsules has increased output up to 30 lumens/watt for some high wattage lamps.

[4] Efficacy of fluorescent lighting varies depending on lamp and ballast types.

Kitchen Lighting

Would one fluorescent light in a kitchen, installed over the sink or under one cabinet, meet the "general lighting" requirements?

No. The general lighting must evenly light the entire kitchen. Two *examples* of acceptable lighting configurations are (1) fluorescent lighting (or other light source with at least 40-lumens/watt) around the perimeter of the kitchen (under or over cabinets), or (2) a fluorescent in the center of the kitchen.

If a customer asks me not to install fluorescent lights in their home, are there any other light sources I can use to meet the kitchen lighting requirements?

Yes, although they may not be readily available, there are products other than fluorescent which meet the lighting requirements of the standards, Section 150(k). The two criteria for the kitchen and bathroom general lighting are (1) a lamp with an efficacy of 40 lumens/watt or more, and (2) the fixtures cannot contain a medium base incandescent lamp socket. Table 2-2 indicates the typical lumens/watt of several common products, some of which meet the required lumens/watt. Specifications from a product's manufacturer can also be used to verify that a product has at least 40 lumens/watt.

Energy Code

Bathroom Lighting (Section 150(k)2 - 3)

2. *Each room containing a shower or bathtub shall have at least one luminaire with lamp(s) with an efficacy of 40 lumens per watt or greater. If there is more than one luminaire in the room, the high efficacy luminaire shall be switched at an entrance to the room.*

   ALTERNATIVE to Section 150(k)2.: A high efficacy luminaire need not be installed in a bathroom if:

   A. *A luminaire with lamps with an efficacy of 40 lumens per watt or greater is installed in a utility room, laundry room, or garage; and*

   B. *All luminaires permanently mounted to the residence providing outdoor lighting shall be installed with the following characteristics:*

      (1) *Luminaires with lamps with 40 lumens per watt or greater; or*

      (2) *Luminaires with lamps with an efficacy of less than 40 lumens per watt shall be equipped with a motion sensor.*

   Note: When using this alternative for multiple bathrooms, after complying with B. for the first bathroom, each additional bathroom in which a high efficacy luminaire is not installed must comply with A. alone.

3. *Luminaires installed to meet the 40 lumens per watt requirements of Section 150(k) 1. or 2. shall not contain medium base incandescent lamp sockets, and shall be on separate switches from any incandescent lighting.*

Construction

Bathroom Lighting

Each room with a shower or bathtub must have at least one luminaire with lamps with an efficacy of at least 40 lumens/watt.

If there is more than one luminaire in the room, the high-efficacy luminaire must be switched at an entrance to the room.

As an alternative, both of the following are required:

1. A luminaire with 40 lumens/watt lamps must be installed in another room with utilitarian functions such as a laundry room, utility room or garage; and

2. All permanently mounted outside lighting must either be at least 40 lumens/watt or equipped with a motion sensor.

When using this alternative for two or more rooms with showers or bathtubs, compliance with item 1. above is sufficient for the second or third rooms since the outside lighting is already in compliance with item 2 above.

Luminaires installed to meet the 40 lumens/watt requirements cannot contain medium base incandescent lamp sockets, and must be on separate switches from incandescent lighting.

Incandescent lighting fixtures recessed into insulated ceilings must be approved for zero-clearance insulation cover (IC-rated) in compliance with Section 150(k)4 (see below).

Installing energy-efficient lamps and fixtures can reduce lighting energy costs without sacrificing the quality or quantity of light available. As indicated in Table 2-2, a 40 watt standard fluorescent lamp is over four times as efficient as a 100 watt standard incandescent lamp.


Inspection

Bathroom Lighting

Each room with a shower or bathtub (no requirement in a half-bath) must have at least one luminaire with lamps with an efficacy of at least 40 lumens/watt, which may be fluorescent or another efficient technology (see Table 2-2 above).

When there is more than one luminaire in the room, the high-efficacy luminaire (greater than or equal to 40 lumens/watt) must be switched at an entrance to the room.

As an alternative, both of the following are required:

1. A luminaire with 40 lumens/watt lamps must be installed in a laundry room, utility room or garage; and
2. All permanently mounted outside lighting must either be at least 40 lumens/watt or equipped with a motion sensor.

Luminaires installed to meet the 40 lumens/watt requirements cannot contain medium base incandescent lamp sockets, and must be on separate switches from incandescent lighting.

Incandescent lighting fixtures recessed into insulated ceilings must be IC-rated in compliance with Section 150(k)4 (see below).


Examples

Bathroom Lighting

If a customer asks me not to install fluorescent lights in their home, are there any other light sources I can use to meet the bathroom and kitchen lighting requirements?

Yes, although they may not be readily available, there are products other than fluorescent which meet the lighting requirements of the standards, Section 150(k). The two criteria for the kitchen and bathroom general lighting are (1) a lamp with an efficacy of 40 lumens/watt or more, and (2) the fixtures cannot contain a medium base incandescent lamp socket. Table 2-2 indicates the typical lumens/watt of several common products, some of which meet the required lumens/watt. Specifications from a product's manufacturer can also be used to verify that a product has at least 40 lumens/watt.


Energy Code

Recessed Lighting (Section 150(k)4)

All incandescent lighting fixtures recessed into insulated ceilings shall be approved for zero-clearance insulation cover (I.C.) by Underwriters Laboratories or other testing/rating laboratories recognized by the International Conference of Building Officials.


Construction

Recessed Lighting

All incandescent lighting fixtures recessed into insulated ceilings must be approved for zero-clearance insulation cover (IC-rated) in compliance with Section 150(k)4.

Although this requirement does not apply to fluorescent fixtures, recessed lighting fixtures left uninsulated significantly increase the heat loss through the roof/ceiling area reducing the effectiveness of the insulation.

Heat lamps are not required to be IC-rated.

Examples

Recessed Lighting

I'd like to know if it is possible to use non-IC rated incandescent fixtures recessed in an insulated ceiling. Although I've never been able to find a bulb heater (heat lamp) that is IC-rated [approved for insulation cover], they are very popular with my customers. Can I use this product?

It is possible to build a box of gypsum board or wire mesh over the fixture in the attic, which can then be insulated. By separating the insulation from the fixture, the fixture is not recessed into the insulated ceiling. As long as there is sufficient clearance between the fixture and the insulation to prevent a fire hazard, this assembly is acceptable for meeting Section 150(k)4 of the standards. **NOTE**: Recessed fluorescent fixtures do not need to be IC-rated).

If insulation is installed between floors of an apartment building (sound-proofing), can I install incandescent fixtures that are not IC-rated?

No. Although this isn't part of the building envelope, standards Section 150(k) states that any incandescent fixtures recessed into an insulated ceiling must be approved for zero-clearance insulation cover.

2.6 SAMPLE FORMS

Compliance/ Plan Check

Mandatory Measures Checklist

A sample of the recommended Mandatory Measures Checklist (MF-1R) is included here. More information about the form are included in Chapter 1. Blank forms are contained in Appendix A.

Compliance/ Plan Check

Installation Certificate

A sample of the recommended Installation Certificate (CF-6R) is included here. More information about filling out the form or inspections tied to the form are included in Chapter 1. Blank forms are contained in Appendix A.

Compliance/ Plan Check

Insulation Certificate

A sample of the recommended Insulation Certificate (IC-1) is included here. More information about filling out the form or inspections tied to the form are included in Chapter 1. Blank forms are contained in Appendix A.